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Improving the Innovation Performance of Ireland's Dairy Industry: An Innovation Systems Approach

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I hereby certify that this material, which I now submit for assessment on the programme of study leading to the award of PhD, is entirely my own work. The author is solely responsible for the content. Neither the thesis nor the original work contained therein has previously been submitted for a higher degree.

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Abstract

This thesis provides new insight into innovation in Ireland's dairy industry. The thesis measures the innovation performance of dairy products on global markets and uses the framework of innovation systems to explore why and how innovation brokers are established as an essential part of the innovation system, and also how systemic instruments are designed and implemented to effect the achievement of policy goals. A variety of methods are used to provide new empirical, theoretical and policy relevant knowledge concerning innovation activity at various points in the Irish agri-food sector. The research is organised into three separate studies.

Study 1 profiles the innovation performance of selected dairy products, viz. butter, cheese and infant milk formula over the time period 2000-2010, using international trade data. The analysis uses a framework, which was developed in Kaplinsky and Readman (2005), to assess product and process upgrading and downgrading as a measure of relative innovation performance, by combining two innovation indicators: unit price and market share. The results show that the innovation performance of the three product categories has declined within the period studied. Although price reduction strategies undertaken by cheese manufacturers have improved its market share, the same approach did not help butter and infant milk formula manufacturers sustain their market position.

Study 2 adopts a problem focused innovation system perspective to explore the phenomenon of part time innovation brokering. Drawing on the innovation brokering literature, the activities of seven part time innovation brokers are examined to identify how they fulfil their role. The empirical setting is the national mastitis control programme, CellCheck, and the seven dairy processor regional coordinators appointed as part time brokers. The study contributes new insights on the activities of part time

innovation brokers and provides recommendations on measures to support these types of brokers in the fulfilment of their role.

Study 3 explores the design of systemic instruments to support functional change in the Irish agri-food sector. Using a case study approach, the Wieczorek and Hekkert framework (2012) is used to examine the design and implementation of two systemic instruments in the Irish agri-food industry: Origin Green and Food for Health Ireland (FHI). The findings show that the framework provides a guide for policy makers in the design and implementation of systemic instruments. Furthermore, the study contributes empirical knowledge on the role, nature and selection of policy tools in the achievement of systemic instrument goals. However, more applications of the framework are needed to draw conclusions on the theoretical role of policy tools in the implementation of systemic instruments.

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1 Introduction

1.1 Overview

This thesis is a study of innovation in the Irish dairy industry from various perspectives and at different locations. Innovation is complex in terms of measurement and determinants. A variety of methods are used to provide new empirical, theoretical and policy understanding of innovation. The research is organised as separate studies, reported over three chapters.

The studies share the common theme of innovation. However, the perspective on innovation is different in each. In Study 1 (Chapter 2), the innovation performance of internationally traded goods is measured. In Study 2 and Study 3 (Chapters 3 and 4 respectively), the focus shifts to the environment in which innovation takes place, namely the innovation system.

The thesis fits within the innovation studies literature. Innovation studies is the social science field of research concerned with understanding the phenomenon of innovation, its environment, processes, facilitation, orchestration and its role in economic and social change (Fagerberg and Verspagen 2009). The conceptual frameworks for the empirical studies in this thesis are formulated from the economics based innovation and innovation systems literature. In Study 1, an economic approach to measuring innovation performance using trade data is applied. In Study 2 and Study 3, the innovation systems framework is utilised to examine an innovation brokerage function and systemic instruments respectively.

In each study, distinct research questions are asked. The research questions are as follows:

- Study 1 assesses the innovation performance of selected Irish dairy products on global markets. Using an economic framework it asks: *What is the relative innovation performance of Irish dairy products on global markets?*

- Study 2 examines the phenomenon of innovation brokers in the Irish dairy industry. The study examines the activities of seven part time innovation brokers, in the national mastitis control programme, to understand how they might be supported in the fulfilment of their role. Using a single case study design the following question is asked: *How might part time innovation brokers be supported in their role?*

- Study 3 explores the design of systemic instruments promoting functional change within an innovation system. Two policy objectives of the Irish agri-food industry are sustainable food production and the development of functional foods. This study explores the implementation of two systemic instruments in the Irish agri-food industry: Origin Green and Food for Health Ireland. Using a case study approach it asks: *How are systemic instruments implemented in the Irish agri-food industry?*

1.1.1 Empirical Studies

Study 1

The global market is a significant destination for Irish dairy produce receiving over 85% of products produced in Ireland in 2010. A focus on innovation is fundamental to sustaining competitiveness in global markets. This competitiveness is a function of innovating as fast as or faster than global competitors. Using international trade data, this study measures the relative innovation performance over the time period 2000 to 2010.

The research question addressed is *what is the relative innovation performance of Irish dairy products on global markets?*

From a descriptive analysis of international trade data, the study identifies infant foods, cheese, and butter as Ireland's most significant dairy product exports, providing the rationale for examining each of these products. To assess the innovation performance over the time period, the framework developed in Kaplinsky and Readman (2005) is applied. Here, using international trade statistics, measures of relative unit value and market share are combined as an indicator of relative innovation performance. The findings conclude that there are good and bad performers across the product categories. The analysis suggests that Irish exporters are engaging in product and process innovation; however, their performance relative to competitors is slower than that of their global competitors. This presents an opportunity for policy interventions that improve the direction and speed of the innovation process (Lamprinopoulou et al. 2014; Hekkert et al. 2007)

Study 2

This study examines the activities of part time innovation brokers in an effort to identify measures that enable them to fulfil their role to coordinate multi-disciplinary actors in the Irish dairy industry. An innovation broker is purposefully positioned within an innovation system to build and maintain interactions between actors. The role can be undertaken on a full time or part time basis. This study focuses on the relatively under explored area of part-time innovation brokers and positions the innovation brokerage function within a problem focused innovation system, to address the '*coordination problem'* identified in Metcalfe and Ramlogan (2008).

The research question asked is *how might part time innovation brokers be supported in their role*?

The activities required of the part time innovation brokers in CellCheck are examined. The inquiry is guided by the three generic functions of innovation brokering: demand articulation, network formation and innovation process management. The study is a case study approach of the national mastitis control programme *CellCheck*, including seven semi-structured interviews with seven individuals undertaking an innovation brokerage role on a part time basis. The programme embarks on 'a new approach to tackling an old problem' on the basis that knowledge on best practice in mastitis control exists; the challenge is bringing these practices into use.

There are two sets of findings from this study. The first set of findings relate to the practices and roles used by the innovation brokers. They include experimentation, context analysis, historical experience, organisational connections, and programme guidelines. The second set of findings relate to the environmental arrangements that influence the fulfilment of the brokering functions. Finally, based on the findings, the study proposes four recommendations for supporting part time innovation brokers.

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Study 3

This study explores the implementation of two systemic instruments in the Irish agri-food industry. Systemic instruments are an integrated approach to addressing problems that hinder innovation processes within the innovation system.

Using a case study approach, the research explores the systemic policy framework developed in Wieczorrek and Hekkert (2012) as a guide for policy makers in the design and implementation of systemic instruments. Two policy objectives of the Irish agri-food industry are sustainable food production and the development of functional foods (Research Prioritisation Project Steering Group 2012). The focus of this research study is on the implementation of two systemic instruments in the Irish agri-food industry: *Origin Green* and *Food for Health Ireland*.

The research question asked is *how are systemic instruments implemented in the Irish agri-food industry?*

The study provides new empirical evidence on the design and implementation of systemic instrument goals. In their conceptual study, Wieczorrek and Hekkert (2012) emphasise the use of policy tools to implement systemic instrument goals. The findings from this study confirm the use of policy tools and that the tools are selected to reflect the nature of the problem, interactions with other tools and the contextual nature of the environment in which it is embedded (Wieczorek, Hekkert and Smits 2012 and Wieczorek and Hekkert 2012). The findings conclude that the framework provides a tool to design interventions to bring about system innovation. However, more applications of the framework are needed to draw conclusions on the theoretical role of policy tools in the implementation.

1.1.2 Contributions

Study 1

First, the research contributes new empirical evidence on the relative innovation performance of Irish dairy products on global markets, more specifically, on Ireland's most significant dairy product markets: infant foods, cheese, and butter.

Second, the Kaplinsky and Readman (2005) methodology for measuring relative innovation performance is applied to a new empirical setting of agriculture. This study identifies two contextual complications when applying the Kaplinsky and Readman (2005) framework to an agricultural context, market supports and the practice of profit switching transfer pricing that need to be considered. The framework can only be vigorously adjusted for the latter, if firm level data is available.

Third, the trade data analysis contributes new understanding on the industrial organisation of the Irish dairy industry. Specifically, the study contributes understanding on the trade performance of infant food products, cheese, and butter in terms of competitors, markets and market share.

Study 2

First, the study contributes four recommendations for supporting the establishment of part time innovation brokers. The recommendations include promoting experimentation and a synergy of practices between the core occupational role and innovation brokerage role; prior analysis of the context in which the innovation brokerage function is to be embedded; the development of templates for brokering activities that fall outside the remit of the core occupational role; and lastly, the establishment of a peer networking group.

Second, the study extends the entities that can undertake an innovation brokerage role to include a network of individuals from different organisations. The study found that this form of an innovation brokerage function could adhere to the core value of credibility, emphasised in the literature on the establishment of an innovation broker.

Third, in a contribution to the emerging field within the innovation systems literature on problem focused, the research in Study 2 and Study 3 confirms the following:

- Innovation brokering is an alternative mechanism to information brokering across structural holes as discussed in the work of Burt (2008a; 2008b; 2007; 2004) and Lomas (2007)

- The innovation brokering practices and support measures identified provide a guide to addressing the '*coordination problem'* identified in Metcalfe and Ramlogan (2008)
- The systemic policy framework developed in Wieczorek and Hekkert (2012) is a useful tool to guide policy makers and researchers in identifying and addressing problems within an innovation system.

Fourth, following on from the previous contribution, Study 2 confirms that the establishment of a part time innovation brokerage function is a way to coordinate interactions in a problem focused innovation system, characterised as a self-organising entity. Furthermore, these findings contribute to the process of conceptualisation of an innovation system.

Study 3

First, the study contributes new empirical knowledge on the design and implementation of systemic instruments thus adding to the under exploited area of systemic instruments. The findings confirm that the policy tools chosen to implement systemic instrument goals reflect the nature of the problem, interactions with other tools and the contextual nature of the environment in which it is embedded (as suggested in Wieczorek, Hekkert and Smits (2012) and Wieczorek and Hekkert (2012)).

Second, the study found that there is evidence of policy makers undertaking a mediation role (as suggested in Smits and Kulhmann (2004)). The findings from the case studies confirm that this is the role required of State agencies in securing the presence of institutions the stimulation of interactions in the Irish agri-food industry. This mediator role supports the process view of an innovation system outlined in Klerkx, Van Mierlo and Leeuwis (2012).

Third, the study contributes new empirical understanding to the theory of innovation systems and innovation policy on using the innovation systems concept as an operational tool. In the context of policy support to improve the innovation performance of agri-food products on global markets, the study suggests that the use of the systemic policy framework developed in Wieczorek and Hekkert (2012) can enrich our understanding of mechanisms that can improve the direction and speed of the innovation process. In addition, the study contributes the second known application of a functionalistic approach to innovation system analysis within an agricultural domain (the first known is Lamprinopoulou et al. (2014)).

Fourth, the case study findings contribute new policy understanding on the implementation of two systemic instruments to achieve two goals in the Irish agri-food industry: the creation of legitimacy around sustainable food production and knowledge development in the area of functional foods. To realise the market opportunities presented for the Irish agri-food industry, attention should be given to the performance of functions that support system wide change in the Irish agri-food industry.

1.2 Rationale for this thesis

The focus of this thesis is on the implementation of value-adding change, the essence of innovation. This focus emerged from the imperative for the Irish dairy industry and its stakeholders to deliver on its opportunities and potential on the evolving context of the early 21st century. In this section, the importance and scope of innovation is discussed, which provided the motivation for the research undertaken in this thesis.

Innovation is the driver of change that can occur at various levels of aggregation – product, firm, value chain, sector level or national level. Innovation at a particular point in the value chain can improve the competitiveness and productivity of the chain as a whole (Anandajayasekeram and Gebremedhin 2009). Fagerberg (2006) outlines three broad roles for innovation in fostering long term economic change. They are as follows.

- To introduce novelty into society and sustain long term economic growth
- To bring about structural changes in production and demand which leads to organisational and institutional change
- To improve competitiveness, allowing successfully innovating firms, regions and countries prosper at the expense of their less able competitors

Innovation has been studied extensively in agriculture; however, studies have differed in their use of the word innovation. It has been used to refer to new technology and the process of technical change (Roling 2009). The first is the use of the term to refer to new inventions. Studies on the diffusion of innovation[1] such as Grilliches (1957) and Rogers (2003) use the word innovation to refer to new technology. Whereas, studies that view innovation as a process of co-creation involving multiple actors in a value chain or sector operating to enhance innovation at farm and higher levels of the system use the term to refer to processes of technical change (Klerkx, Van Mierlo and Leeuwis 2012; Roling 2009).

These processes of co-innovation can be understood and supported using an innovation systems approach, which is becoming more prominent in agriculture (EU SCAR 2012; Roling 2009; World Bank 2006). Following an innovation systems perspective, innovation is not attributed to science or markets but to interactions among stakeholders in opportunities for improvement (Roling 2009). More specifically, to enhance innovation, the challenge is not to transfer technology to users but to develop the innovative capacity of stakeholders. Although the focus is shifting from technology to innovation, the technology supply push model remains the most widely used model of

[1] Studies on the diffusion of innovation examine the rates of technology adoption.

innovation among agricultural scientists (Roling 2009; World Bank 2006). Other models used in agriculture include farmer driven innovation, participatory development, market induced innovation and innovation systems. Each model is explained in turn. The farmer driven models relate to the development of experimental knowledge by supporting farmers in the identification and stimulation of knowledge and the promotion of the results. The participatory development model relies on developing useful and appropriate technologies by carrying out exploratory studies on issues and situations that could make a contribution (Roling 2009). The market induced model is also known as the 'agricultural treadmill' first devised by Cochrane (as cited in Roling 2009). This is a neo-classical economics model. The model advocates farmers are small producers in a global market producing similar produce. This results in a downward pressure on price. The introduction of a new technology enables early adaptors to capture a profit but eventually widespread diffusion leads to over production, a reduction in price and adoption becomes essential to staying in the market. Others then absorb the resources of farmers that cannot keep up in a process called 'scale enlargement'. Therefore for innovation, the treadmill needs to be feed new technologies.

Two global agricultural challenges are food security and the mitigation of climate change. Food security refers to the availability, accessibility, use and stability of food (World Trade Organisation 2013; Food and Agriculture Organisation of the United Nations 2009). Climate change poses risks to global food security and the livelihoods of agricultural stakeholders. There is a particular need for agriculture to commit to the 2020 targets set out by the Kyoto Protocol in 1997. In particular, agriculture is the largest contributor to Ireland's Green House Gas (GHG) emissions producing 32% of all emissions (Environmental Protection Agency 2013). Therefore it is of paramount importance that the sector commits to achieving its targets to enable the EU achieve a reduction in GHG emissions by 20%. In addition to research and technology, efforts to build the innovative capacity of stakeholders to respond to these challenges are required (World Bank 2006). An innovation systems approach is a useful tool for both understanding and informing approaches to addressing these challenges.

The innovation systems approach is the innovation model used under the agricultural European Innovation Partnership (EIP). More specifically, the Agricultural and Knowledge Innovation System (AKIS) is employed by the European Commission to understand innovation in terms of the organisations involved, the links and interactions between them and the institutional infrastructure of incentives and budget mechanisms. The EIP is a new instrument used to enhance innovation among agricultural stakeholders across Europe. The EIP aim is to promote faster and wider transposition of innovative

solutions into practice (EU SCAR 2012). The EIP creates added value by facilitating information flows between research and practical farming. This is achieved through the formation of partnerships using bottom-up approaches and linking farmers, advisors, researchers, businesses, and other forms of actors in operational groups (Van Oost 2013). Through these operational groups the aim is to facilitate faster knowledge exchange to generate new insights and ideas, and synergise existing tacit knowledge into focused solutions that are quick to put into practice (Van Oost 2013; EU SCAR 2012).

A focus on innovation can drive economic and social change in Ireland's agri-food industry. Agri-food relates to primary agriculture (agriculture, fishery and forestry), food and drinks and wood processing. The importance of innovation to drive economic and social growth in the industry is illustrated in the following paragraphs.

In Ireland, the agri-food industry is the largest indigenous sector. The industry maintains approximately 230,000 jobs and has an annual turnover of €24 billion, representing 23% of total industry turnover in Ireland (Department of Agriculture Food and the Marine 2013; Food and Drink Industry Ireland 2013). It is classified as a low-tech industry as defined by the OECD[2] (2011) . Low-tech and high-tech are used as a proxy for innovative efforts. However, recently several authors have argued a role for low-tech industries in the innovativeness of industry as a whole and therefore, it is important to understand and support their specific innovation needs (Hirsch-Kreinsen, Jacobson and Robertson 2006; Von Tunzelmann and Acha 2006). This requires extending the focus beyond the creation of knowledge (R&D) to encompass the factors that affect the demand and use of knowledge for innovation (World Bank 2006). The innovation systems approach is a valuable tool to both understand and support innovation.

[2] The OECD (2011) defines high, medium and low-tech industries based on the percentage of turnover allocated to R&D. For high tech it is greater than 5%, for medium tech it's between 3% and 0.9%and for low tech it's less than 0.9%.

The following production targets for the Irish agri-food industry have been set out in the industry's growth strategy, 'Food Harvest 2020'. The targets are based on the principles of smart, green growth. The targets to 2020 include:

- An increase in the value of primary output by €1.5billion representing a 33% increase based on 2007-2009 average
- An increase in value added output by €3 billion representing a 40% increase compared to 2008
- Growth in exports to €12 billion representing a 42% increase based on 2007-2009 average

(Department of Agriculture, Food and Fisheries, 2010a, p8).

A successful innovating ecosystem is critical for delivering on these targets, to improve competitiveness that leads to economic success and development across agri-food (Fagerberg 2006; Smith 2006; OECD and Eurostat 2005). The focus is on enhancing innovation (product, process, organisational and marketing) to support smart, green growth (Department of Jobs Enterprise and Innovation 2012; Bell and Shelman 2010; Department of Agriculture Fisheries and Food 2010a). More specifically, the strategy for smart development promotes investment in knowledge, skills and innovation and identifying opportunities for collaboration across the supply chains and with competitors. The green strategy for growth seeks to capitalise on Ireland's grass based food production systems by building credentials around its green production systems to market to global customers. National efforts to build credentials around Ireland's green image, leading to the development of a sustainability agenda have been set out for the agri-food industry (Bord Bia 2013b; Department of Environment Community and Local Government 2012). This is driven by the growth in demand for sustainably produced produce among international customers. In particular, the dairy industry is dependent on the export market with its high volume of milk production relative to Ireland's population. Sustainable food production is centred on three pillars: environmental, economic and social. The environmental pillar centres on preserving the environmental resources such as soil, water and natural habitats. The economic pillar centres on ensuring the economic viability of farming systems. The social pillar centres on building and improving the livelihoods of agri-food producers to improve the economic and social conditions of rural communities. Sustainable food production requires change in the activities of all producers across the agri-food supply chain.

Study 1

The dairy industry is a major contributor to the agri-food industry in terms of exports. In 2012, dairy product exports accounted for 29% of total agri-food exports which were valued at €9 billion (Department of Agriculture Food and the Marine 2013). To achieve growth across agri-food exports and employment, Food Harvest 2020 projects a 50% increase in milk production for the dairy industry. Furthermore, the rising global demand for dairy products and the expected increase in milk supplies, post abolition of European Union (EU) milk quotas in 2015, present opportunities for dairy product exports. Innovation can help deliver on these opportunities by improving the competitiveness of Irish dairy products on global markets.

The global market is of particular importance as over 85% of dairy products produced in Ireland are exported. Innovation in dairy products is achieved through value adding activities i.e. product upgrading. Product innovation in the form of new or improved products or production processes can improve the competitiveness and support economic success in the Irish dairy industry. The ways in which innovation can support economic success are as follows. First, product innovation can support an increase in market share and thus revenues (Kaplinsky and Readman 2005). Second, an increase in process efficiency through innovation can lead to lower product prices relative to competitors which can stimulate demand and increase revenues (Balzat 2006; Kaplinsky and Readman 2005). Third, an increase in revenues due to market success enables firms to invest in innovative activity (e.g. R&D) to sustain market position. Lastly, increased competitiveness and/or profitability can stimulate the creation of jobs which is a source of economic growth (Balzat 2006).

However, the full potential for economic success is achieved only if innovation activity is undertaken as fast as or faster than competitors, a situation referred to as upgrading. Therefore, Irish dairy exporters are required to continuously engage in innovation activities to sustain long term competitiveness. To assess the performance of Irish dairy products on global markets, Study 1 measures the upgrading performance of three Irish dairy exports – infant foods, cheese, and butter - over the period 2000-2010 using international trade data.

To achieve an increase in exports, it is vital to support programmes that improve the speed of innovation in the agri-food sector. The findings from this thesis show that the innovation systems approach is a valuable tool to understanding and supporting innovation processes. From an innovation systems viewpoint, policy intervention is justified based on systems failure and not market failure.

Study 2

Innovation is increasingly important to address the grand challenges faced by global agriculture such as food security and the mitigation of climate change. The innovation systems approach to understanding innovation as a process of co-creation among a network of multi-disciplinary actors is gaining recognition as a way to enhance innovation. A new subject of the innovation systems literature is the idea of innovation brokers whose commercial goal is to facilitate the co-creation of innovation by stimulating interaction and collaboration between disconnected actors in the network (Kilelu, Klerkx and Leeuwis 2013; Klerkx and Nettle 2013; Devaux et al. 2009; Klerkx and Leeuwis 2008a). These interactions enable knowledge acquisition (relating to knowledge generation, development, diffusion and application) and learning to take place. The establishment of an innovation broker is a way to build connections between actors in agricultural innovation systems (EU SCAR 2012; Klerkx, Hall and Leeuwis 2009).

An innovation brokering role can be undertaken by an organisation or an individual on either a part time or full time basis. Although part time innovation brokers are recognised in the literature, the research on innovation brokers has been limited to full time innovation brokers known as specialised innovation brokers (Batterink et al. 2010; Klerkx and Leeuwis 2009a; Klerkx and Leeuwis 2008a). For this reason, Study 2 examines how the identified part time innovation brokers, in the Irish dairy industry, span the structural holes across the problem focused innovation system, CellCheck. The study examines the activities of seven individuals undertaking a part time innovation brokering role in an attempt to provide new theoretical and empirical knowledge on the activities of part time innovation brokers and furthermore, new recommendations on supporting part time innovation brokers.

Study 3

Advancing from the innovation systems viewpoint that innovation is non-linear, systemic and uncertain, then *how best can we support it*? Farmers and food manufacturing firms are the direct agents of innovation across the agri-food industry (Edquist 2011). As such, the role of institutes such as government agencies, interest groups and non-governmental organisations is indirect, more specifically to influence the environment in which innovation takes place. Their role is to change, reinforce and improve the context referred to as the innovation system. These activities to influence the innovation process are defined as innovation policy (Edquist 2011).

Recently, the term systemic instrument is used to denote policy efforts that support the systemic view of innovation. This is one approach to using the innovation systems framework as an analytical tool (Word Bank 2006). Systemic policy frameworks to guide the design of systemic instruments are new tools in the policy arsenal, which are specifically aimed at analysing and resolving innovation system problems. Drawing on two cases of systemic instruments in the Irish agri-food sector, Study 3 explores the framework developed in Wieczorek and Hekkert (2012) as a guide to the design and implementation of systemic instruments.

1.3 Theoretical Framework of this Thesis

The success of innovation efforts as well as the support being given to stakeholders to deliver innovatively on its specific opportunities and targets is the focus of this research. The thesis contributes to the measurement, orchestration and design of policy towards innovation in the Irish dairy industry. The research follows the trend in the literature, going beyond the analysis of innovation towards a methodology for intervention. The research is organised across three empirical studies. The theoretical framework for the research is discussed in this section.

The aim of this research is to understand innovation in the Irish dairy industry by examining innovation performance, the coordination of interactions for problem focused innovation and policy approaches to system innovation. In this section, the theories and concepts used to explain and understand these three aspects of innovation are discussed. These theories and concepts were drawn from innovation scholars located across the disciplines of economics, management, communication studies and sociology. This approach reflects the multi-disciplinary nature of the body of literature on innovation that according to Fagerberg (2006, p3) '*reflects the fact that no discipline deals with all aspects of innovation*'. A large diverse literature has emerged since the writings of the social scientist Joseph Schumpeter (1883-1950). In their survey of innovation scholars[3], Fagerberg and Verspagen (2009) identified economics as the most common disciplinary background, representing 58% of respondents, followed by engineering at 9%, management at 6% and sociology at 5%.

These social science disciplines would answer these research questions in different ways. Study 1 applies a mainstream economics approach to measure innovation performance using trade data. It calculates the economic metrics of relative unit value and market share to measure innovation performance. Study 2 and 3 draw on the theoretical field of innovation systems. Study 2 was informed by the innovation brokering literatures developed by the disciplines of communication studies and management studies. Study 3 was principally informed by the applied science discipline of technology studies.

1.3.1 Defining Innovation

Innovations are new creations of economic and/or social significance (Edquist 2011). Innovation is the ability to introduce, diffuse and use new knowledge at least as fast and efficiently as its competitors (Johnson 2011; Kaplinsky and Readman 2005).There are two distinct ways to define innovation. In one, innovation is characterised according to

[3] This is defined as scholars that identify themselves with innovation studies.

how radical the change is relative to current technology. In the second characterisation, different types of innovation are distinguished, as for example, in the Oslo Manual (2005). Here, the four types of innovation are identified as product, process, new marketing methods, and new organisational methods, which include changes in business practice, workplace or external relations. Innovation occurs when the new product, process, marketing method or organisational method is brought into use.

There is agreement across the innovation literature that although invention and innovation are closely linked they are different (Fagerberg 2006; World Bank 2006). Invention is the occurrence of an idea i.e. for a new product or process whereas innovation is the process to bring a new idea into use (Metcalfe and Ramlogan 2008; Fagerberg 2006). The occurrence of innovation does not require a new invention, innovation can occur if just new to the organisation or sector (World Bank 2006; Smits and Kuhlmann 2002). The measurement of innovation is a complex challenge (Fagerberg 2006; Smith 2006; Kaplinsky and Readman 2005), relating to the identification of the appropriate measures to use.

1.3.2 Measures of Innovation

Measures of innovation have primarily used innovation inputs and outputs as indicators of innovation (Fagerberg 2006; Smith 2006; OECD and Eurostat 2005). Input measures include R&D and non R&D inputs such as interactions and marketing activities (OECD and Eurostat 2005). The most widely used innovation indicator is 'R&D Intensity' which is the ratio of the business expenditure on R&D (referred to as BERD) of an industry or country to total production or value added. Output measures include bibliometric analysis[4] and patent data which is the most widely used measure of innovation output.

There are limitations to the use of these input and output measures as innovation indicators. Firstly, these measures usually reflect science and technology activities. For example, R&D data measures only one of several inputs into innovation (OECD and Eurostat 2005). Similarly, the use of patent data as an innovation indicator does not account for the potential inability to develop invention into a commercial innovation (Smith 2006). Secondly, in relation to input measurements, they provide no insight into the effectiveness of inputs on the innovation process (Kaplinsky and Readman 2005). Lastly, input and output measures cannot account for the differences in technology needs across sectors or efficiency in the innovation process (Kaplinsky and Readman 2005).

[4] The analysis of publications and citation data.

An alternative way to measure innovation is through measures of competitiveness using trade data. Using trade data, there are two measures of innovation: unit value analysis and market share. Unit value analysis of internationally traded goods is an indicator of quality competition (Kaplinsky and Santos Paulino 2005). High unit values reflect innovative activity and thus changes in quality. Low unit value reflects little innovative activity. Market shares are an indicator of international competitiveness on global markets (Montobbio and Rampa 2005; Narula and Wakelin 1998). A rise in market share can reflect product innovation (causing rising product values) or a reduction in costs (due to process efficiency or decrease in input costs) and an increase in traded volumes (Kaplinsky and Readman 2005). Kaplinsky and Readman (2005) developed a new indicator of innovation performance by combining these two metrics; more specifically looking at relative unit value and market share of internationally traded goods. This indicator implies that innovation will only improve competitiveness if the innovation rate is lower than that of competitors. The Kaplinsky and Readman (2005) approach is employed in Study 1 to measure the comparative innovation performance of Irish dairy products traded on international markets.

1.3.3 The Co-Creation of Innovation

In the paradigm of an innovation system, innovation is a co-creative process between multiple actors that cooperate and coordinate their activities to generate new knowledge and practices for desired change (Klerkx and Nettle 2013; Devaux et al. 2009). This process involves the combination of several types of knowledge (Fagerberg 2006; Smits 2002). Information sources include all resources in which information is embedded such as ideas, skills, technologies, information (e.g. market needs) and learning. The information type may be codified or tacit in nature. Smits (2002) categorises information sources for innovation as 'hardware', 'software' and 'orgware'. Hardware refers to the material equipment; software refers to knowledge in terms of manuals, digital content and tacit knowledge; and orgware refers to the organisational and institutional conditions that influence the development of an invention into an innovation and the functioning of an innovation. The linkages between actors to facilitate knowledge and learning can take various forms such as partnerships, commercial transactions and networks.

The innovation process is characterised as non-linear, systemic, and uncertain (Smits and Kuhlmann 2004). The first characteristic of non-linearity, refers to innovation not being linearly driven by research but involving a continuous level of interaction and feedback between users and producers (Smits and Kuhlmann 2004). Innovation is viewed as an

interactive process, and not a linear model which holds true only for a small number of innovations (Fagerberg 2006; Kline and Rosenberg 1986).

The second characteristic, the systemic nature of innovation, relates to the multiplicity and diversity of actors and interactions involved in the innovation process (Edquist 2006; Smits and Kuhlmann 2004). Based on this, innovation must be examined in the context of a system (Fagerberg 2006). From this viewpoint, innovation occurs in interconnected networks of actors and is a function of knowledge and learning accessed through interactions (Lundvall 2007; Fagerberg 2006; World Bank 2006; Smits and Kuhlmann 2004). Private and public actors increasingly seek network opportunities to exchange information and collaborate with their suppliers (Helper, MacDuffier and Sabel 2000), customers or users (Lester and Piore 2004) and competitors (Hamel, Doz and Prahalad 1989). This facilitates a process of continuous knowledge acquisition and learning which makes the uncertainty of innovation, the third characteristic of innovation, more manageable (Sabel and Simon 2012).

The uncertainty arises from the unpredictable nature of the innnovation process in that technology performance and market behaviour cannot be forecasted (Smits and Kuhlmann 2004). The inability of actors to predict the nature of the innovation or its performance characteristics, prior to engaging in the collaborative process, brings about uncertainty which hinders the success of the process. This uncertainty contrasts the linear model assumption that innovation requires the completion of a number of stages namely basic science leads to applied science leading to innovation (Kline and Rosenberg 1986). To address this uncertainty, Gibson, Sabel and Scott (2009) suggest a specific type of contracting between parties referred to as ‘contracting for innovation’. Here, contracts are designed using explicit and implicit relational contracting which reinforce collaborative agreement by raising switching costs.

As shown in Figure 1.1, although the firm has a direct influence on the innovation process, the core assumption of the innovation systems approach is that no firm or actor innovates in isolation (Fagerberg 2006; Klein Woolthuis, Lankhuizen and Gilsing 2005). Furthermore, the determinants of innovation are not only found in individual firms or research institutes but in the broad social and economic environment in which firms are embedded. For example, the infrastructure and institutional framework play an influencing role on the propensity of an actor to interact and learn, access, and share knowledge for innovation (World Bank 2006).

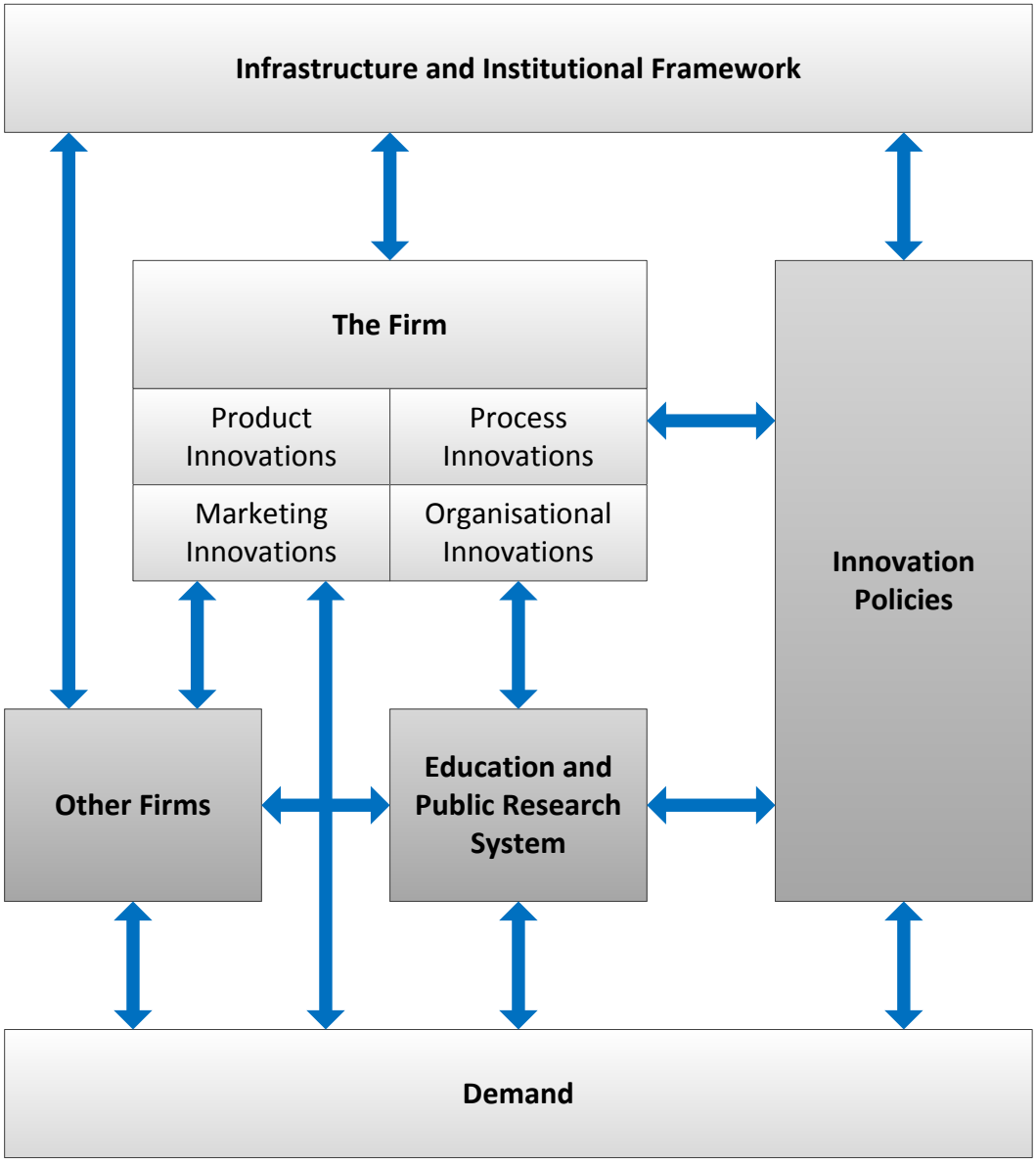

Figure 1.1 Innovation systems view of innovation

Source: Oslo Manual, OECD and Eurostat (2005)

The innovation systems literature is large and wide reaching. An overview is presented in the next section. This is to provide the foundations for the theory and concepts drawn from this literature in Study 2 and Study 3 which are used to explore mechanisms that may enhance the innovation capacity of the dairy industry and its stakeholders to deliver on the opportunities to improve the innovation performance of dairy products on global markets.

1.3.4 The Innovation Systems Approach

The innovation systems concept emerged in the late 1980s when Freeman (1987) coined the expression 'national innovation system' (as cited in Edquist 2006). The concept emerged from the analysis of the determinants of successful industrial economies such as

Japan. Scholars' such as Freeman (1987), Lundvall (1992) and Nelson (1993)[5] observed that these economies possessed a national innovation system (NIS) (as cited in World Bank 2006). The concept developed as an alternative to the neo-classical economics approach to analysing the problems of competitiveness, economic growth and development (Edquist 2006).

In this thesis, an innovation system is defined as
'*a network of organisations, enterprises and individuals focused on bringing new products, processes and new form of organisation into use together with the institutions, and policies that affect their behaviour and performance*'
World Bank (2006) (p vi).

There are two approaches to using the innovation systems framework: as an analytical tool and, as an operational tool. The first approach applies the framework to analyse the structural organisation, operation and performance of an innovation system. It is used to model the comparative innovation performance of an innovation system using indicators of knowledge generation, indicators of knowledge diffusion, and indicators of knowledge use (employment, turnover, and growth) (Balzat 2006; Carlsson et al. 2002). This approach has primarily been used to explain past economic performance of national economies.

The second approach uses the framework to inform putting innovation into action (i.e. operationalising innovation). The innovation systems framework is used to identify, analyse and provide insight into context appropriate interventions. The research in Study 3 on the design and implementation of systemic instruments contributes new empirical understanding to the theory of innovation systems and innovation policy on using the innovation systems concept as an operational tool. More specifically, the systemic policy framework developed in Wieczorrek and Hekkert (2012) and discussed in this thesis in Study 3 is one approach to using the innovation systems framework as an operational tool.

Elements of an Innovation System

There is agreement in the literature that an innovation system comprises of structural elements, and the relations between them (Edquist 2006; World Bank 2006). In the literature four structural elements can be distinguished, viz. actors, interactions,

[5]Nelson and Lundvall applied different approaches to their study of NIS. Nelson emphasises empirical case studies whereas Lundvall was concerned with theory development

institutions, and infrastructure[6] (Table 1.1). Each element is recognised as a determinant of innovation and collectively these elements influence the environment for innovation (Bergek et al. 2008; Edquist 2006; World Bank 2006).

Table 1.1 The role and types of structural elements within an innovation system

	Role	**Type**
Actors	Undertake and/or support innovation activity (knowledge generation, development, diffusion and use)	Firms, individuals, interest groups, intermediary organisations, research organisations (public and private) and government and its agencies
Interactions	Facilitates knowledge acquisition and learning	Formal (networks, partnerships) and informal (peer groups)
Institutions[7]	Influence actor behaviour and interactions	Hard such as rules, laws, regulations and instructions Soft include customs, norms, habits and routines
Infrastructure	The physical infrastructure that helps actors to function and influences activities and interactions	Transport system, R&D system, financial system and policies

Source: Adapted from Wieczorek and Hekkert (2012); Edquist (2006); World Bank (2006); Klein Woolthuis Lankhuizen et al. (2005).

The organisational arrangement varies across innovation systems. As such, no two innovation systems are the same and a universally optimal innovation system does not exist (Hall 2007; World Bank 2006). The actors, interactions, and institutional and infrastructural set up of an innovation system are context specific (Malerba 2006).

[6] Previous studies such as Balzart (2006) and Bergek, Jacobsson et al. (2008) have excluded infrastructure as an element in their analysis of innovation systems

[7] The concept of institutions has different interpretations in the innovation systems literature. It can represent the rules of the game or organisations in an innovation system. In this thesis institutions refer to the rules of the game as defined by Edquist (2006) and not organisations.

According to Hall (2007, p22) the model emphasises that what is required are '*coordinated networks of actors relevant to specific challenges or opportunities and locations - accompanied by supporting policies and ways of working specific too those challenges, opportunities and locations*'.

An innovation system can be aggregated at alternative levels including geographically (such as national, regional and local), production activity (sector or commodity) or problem definition (Anandajayasekeram and Gebremedhin 2009; World Bank 2006; Malerba 2002). These innovation systems are not assumed mutually exclusive but overlapping. This research does not adopt one category of an innovation system. In Study 2, the research inquiry of innovation brokering is positioned within a problem focused innovation system. In Study 3, the systemic policy framework, developed within the technological innovation systems literature, is used to explore the activities of systemic instruments.

Klerkx, Van Mierlo and Leeuwis (2012) distinguish between a hard and soft view of the innovation systems concept. The hard view is where it is assumed that the innovation system has a clear boundary and a common goal. This view developed from the general systems theory (Edquist 2006). The system exists independent from the observer and can be analysed and formulated to address an unambiguous goal. In contrast, the soft view emphasises that individual goals and perspectives of interdependent actors are likely to differ (Klerkx, Van Mierlo and Leeuwis 2012). This implies that the system and its boundaries are understood by actors in different ways. From the soft systems viewpoint, the achievement of coordination among multiple actors can be a challenge due to the opportunistic behaviour of actors and a lack of trust, incentive, capacity and rules (Ekboir and Rajalahti 2012; Klerkx and Gildemacher 2012).

From an innovation systems standpoint, innovation is co-evolutionary in nature (Kilelu, Klerkx and Leeuwis 2013; Edquist 2006). As such, the composition of the system is continuously evolving to address emerging innovation needs (Klerkx, Aarts, Leeuwis 2010). The dynamics within the innovation system can be distilled to three processes: system (Smits and Kulhmann 2004; Wieczorek and Hekkert 2012; Sabel and Zeitlin 2012; 2008), network (Burt 2008a; 2008b; 2007; 2004) and interactions (Lester and Piore 2004).

System processes support the achievement of system wide change, so called system innovation (Edquist 2011). Smits and Kuhlmann (2004) identified five types of system processes within an innovation system: the management of interfaces, the building and

organising of innovation systems, providing a platform for learning, providing an infrastructure for strategic intelligence, and stimulating demand articulation, strategy and vision development. On the premise that innovation is a non-linear, systemic and uncertain process (Smits and Kuhlman 2004), it is assumed that no actor can have a panoramic view of a system problem or rely on their individual abilities to cultivate system innovation (Sabel and Zeitlin 2012; 2008). It requires collective action among all actors within an innovation system to deliver system innovation (Edquist 2011; Klein Woolthuis, Lankhuizen and Gilsing 2005). These collective activities organised and managed at the level of the system are depicted in this thesis as system processes. Examples of system processes in the recent literature include problem focused innovation systems (Metcalfe and Ramlogan 2008), systemic instruments (Klein Woolthuis, Lankhuizen and Gilsing 2005; Wieczorek and Hekkert 2012) and experimental networks (Sabel and Zeitlin 2012; 2008). These processes comprise of a network of diverse actors (public and private) and the boundaries of the organisational regimes can be overlapping and unclear (Sabel and Zeitlin 2012; 2008). They arise from problems that cannot be solved by established knowledge and the policy makers and private and public actors share uncertainty on how to resolve them. They are organised by policy makers to address the uncertainty of a situation that overwhelms hierarchical governance and 'command-and-control' regulations in a setting. The actors involved manage the activities through joint exploration of the situation and the potential ways to address it. The activities involved are multi-level and continuously changing in light of the impact in a specific context (Sabel and Zeitlin 2012; 2008; Wieczorek and Hekkert 2012; Metcalfe and Ramlogan 2008).

The participation in networks provides an opportunity for actors to identify other network participants who are already solving (part of) a specific problem or a problem closely related to it (Sabel 2005). However, weak or missing connections between actors hinder collective action activities across the innovation system. Burt (2007; 2008a; 2008b) refers to missing relations between groups of actors within a network as 'structural holes'. They arise when actors focus on activities within their actor group which creates holes in the information flows. Actors within a group share a similar characteristic such as their location of residence, work occupation or sporting interest. Over time, communication within the groups rather than between the groups takes prominence leading to actors within a group developing similar views and opinions on conversational issues and a language emerging, which all members of the group are familiar (Burt 2008a; 2008b; 2007). This leads to explicit knowledge, previously interpretable by others outside the group, becoming tacit knowledge such that only the members can understand (Burt

2008a; 2008b). A reliance on tacit knowledge can cause 'lock-in effects' that hamper innovation (Bergek et al. 2008; Lester and Piore 2004; Sabel 2005).

Bridging structural holes provides opportunities for information brokers to bring knowledge and ideas from one place to another (Lomas 2007; Salter and Tether 2006; Burt 2008a). This mechanism of brokerage is used to build relations between actors to improve the social structure of the network (Burt 2004). The value to network processes is not about knowing the specific groups in detail but knowing how the groups differ (Burt 2008a). An individual or organisation that possesses connections across groups are familiar with alternative the opinions and behaviours (Burt 2004). Therefore, those that undertake an information brokering role achieve competitive advantage over peers confined to a single group (Burt 2007). Burt (2008a; 2008b) characterises information brokers as holding high status among the network actors and possessing a social network that spans multiple individuals and groups that are disconnected in the social structure (Burt and Merluzzi 2013). As a by-product of the process to synthesise relevant information and communicate this across the groups, the brokers develop cognitive and emotional skills (Burt 2008b). The cognitive skills relate to the ability to compare and synthesis different opinions and practices of actors whereas the emotional skills relate to the ability of the broker to interpret, engage and motivate actor groups.

An alternative conceptual approach to information brokering across structural holes developed in Burt (2008a; 2008b; 2007) and Lomas (2007) is the concept of innovation brokering. The activities of an innovation broker are broader than that of the information broker. The role of an innovation broker includes the function of information brokering in its efforts to create an enabling environment for effective policy formulation and implementation, development and innovation (Klerkx et al. 2012; Fisher 2011). This difference highlights the differences in the terms information, knowledge and innovation which are used interchangeably in the network literature (Fisher 2011; Klerkx et al. 2012; Ackoff 1989). Ackoff (1989) states that the difference between knowledge and information is that knowledge comprises of the testing and evaluation of information. Therefore, knowledge relies on information to change the grounds for action or the capability of an individual or organisation for more effective action (Ackoff 1989). The difference between knowledge and innovation is that innovation relies on alternative sources and types of knowledge to create an enabling environment for effective change (Fisher 2011; Smits 2002).

In the context of an innovation systems framework, the third type of process fundamental to innovation is interactions. Through an examination of innovation strategies in cases of

new product development in fields such as cell phones, blue jeans and medical devices, Lester and Piore (2004) identified two components of innovation: analytical and interpretative processes. The findings from their study show that to innovate successfully, it is important to use interpretation alongside analysis as a tool to cultivate innovation. Lester and Piore (2004) argue that interpretation is important at the start of developing new ideas whereas analysis is required when the ideas are selected.

The analytical approach is the most dominant approach identified by Lester and Piore (2004) in the cases. The approach encompasses rational problem solving and involves working through a chain of decisions. These types of interactions are applicable to the hard view of an innovation system. The goal of the interactive process and its boundaries are clearly identifiable.

In contrast with the analytical approach, the interpretative process encompasses explorative activities to identify the different views of actors on the same topic. These types of interactions are applicable to a soft view of an innovation system. The interpretative approach is an open ended, context dependent and undetermined process that requires ambiguity and continuous conversations. These conversations explore the different views of participants and find ways to work through the ambiguity to construct meaning. Unlike the chain of decisions in the analytical process, participants have no idea how the conversation will evolve but this uncertainty is the key resource from which new ideas emerge (Lester and Piore 2004).

Lester and Piore (2004) criticise the reduction in spaces for interpretation. The authors' argue the importance for actors to continuously seek out opportunities to engage in exploratory, interpretative conversations with a variety of actors. In a contribution to system and network processes, these conversations provide the capacity to integrate across organisational boundaries, to experiment and to explore ambiguous situations so to address the emerging opportunities and challenges for innovation.

The system, network and interactive processes of an innovation system can be depicted in a number of ways including collective action (Meinzen-Dick and Di Gregorio 2004; Ostrom 1990), private collective innovation (Von Hippel and Von Krogh 2009) and a triple helix (Etzkowitz 2008).

Collective action represents innovation as a collective voluntary endeavour undertaken by a group of people that share a common goal (Meinzen-Dick and Di Gregorio 2004). It is the shared common goal that brings about coordinated interaction between the actors for

innovation. Collective action applies to the provision of public goods where a public good is defined as non-excludable and non-rivalry (Ostrom 1990). Developers of knowledge (the participants) make it a public good by unconditionally supplying it to a common pool. The model prescribes achieving collective action by excluding those that do not contribute collectively; creating incentives to encourage contribution; and reducing the expected gain for individuals so that it is lower for those who do not contribute.

The private collective model developed in Von Hippel and Von Krogh (2009), depicts innovation as a combination of the private investment and collective action. The authors argue that open source software development projects illustrate this type of model. Participants use their own resources to privately invest in the development of software code viewed as innovation. The private investment model assumes that innovation is supported by private investment and private returns can be appropriated from such investments. To support this, the government grants innovators limited rights to the innovations they generate via intellectual property mechanisms such as patents, copyrights and trade secrets. These rights enable innovators to receive private returns on their innovation related investments. The collection action among participants in the private collective model relinquishes the social loss problem associated with restricted access to knowledge of the private investment model (Von Hippel and Von Krogh 2009).

In this thesis, as innovation occurs within interconnected networks of actors and is a function of knowledge and learning accessed through interactions (Lundvall 2007; Fagerberg 2006; World Bank 2006; Smits and Kuhlmann 2004), innovation is depicted as a triple helix. The triple helix model of innovation emphasises building relations between university, firms, and government to form a network with the capacity to produce, transfer and apply innovation in response to economic and social needs (Etzkowitz 2008). The triple helix comprises of system, network and interactive processes. Based on interdependent relations with other firms, universities and government, the formation of networks is central to innovation strategy. The government plays an encouraging role acting as a public venture capitalist, cooperative creator and implementer of policy initiatives.

1.3.5 Conceptualising an Innovation System

In this section, the three interpretations of an innovation system identified in Klerkx, Van Mierlo and Leeuwis (2012) are discussed. The three distinctly different ways to conceptualise an innovation system are as a support infrastructure, a process or a set of functions (Klerkx, Van Mierlo and Leeuwis 2012; Bergek et al. 2008). The first

interpretation, as a support infrastructure, is the principal view in the innovation systems literature. For example, traditionally the framework was used to describe and examine past economic performance in developed countries (i.e. as an analytical tool). From this position the innovation system has a goal - to support innovation. In addition, an innovation system has clear boundaries defined geographical or based on production activity (Malerba 2002). This conceptualisation of the innovation system, as having a common goal and clear boundaries, resembles hard systems thinking. The innovation system framework is used to understand the extent to which the infrastructure is supporting or constraining innovation. To identify this, static analysis of the actors, their interactions, and the institutional and infrastructural frameworks that influence innovation outcomes is undertaken (Klerkx, Van Mierlo and Leeuwis 2012).

The second interpretation of an innovation system as a process centres on the viewpoint that the innovation system is an evolving entity. Changes that occur in innovation system relate to the composition of actors, interactions, the institutional framework and/or the infrastructure of the system. This is referred to in the literature as a self-organising entity. In terms of innovation analysis, the approach involves analysing the dynamic activities of actors in reaction to changes occurring in markets, technologies, and institutions (Klerkx, Van Mierlo and Leeuwis 2012). Wieczorek, Hekkert and Smits (2011) emphasise that despite the degree of self-organisation of actors, to achieve objectives, systems require organisation and coordination. As although actors share commonalities they are heterogeneous (Ekboir and Rajalahti 2012; Malerba 2006). Actors differ in terms of individual goals and perspectives. The conceptualisation of an innovation system as a process has similarities with soft systems thinking. In the recent innovation systems literature, the potential of innovation brokers as coordinators of interactions between heterogeneous actors has been discussed. Their role in building and maintaining linkages between actors to facilitate interactions for knowledge and learning flows is discussed further in Study 2. This implies that an innovation brokerage function is useful in for this type of conceptualisation of an innovation system.

The third interpretation of an innovation system, outlined by Klerkx, Van Mierlo and Leeuwis (2012), is as a set of functions. The analysis of this type of innovation system is on the fulfilment of a predefined set of functions that are deemed important processes within the system. Weak or missing functions cause problems in an innovation system (Bergek et al. 2008; Hekkert et al. 2007; Johnson 2001). The literature shares an understanding on the important functions within an innovation system. These are identified and explained in Table 1.2. Wieczorek and Hekkert (2012) argue that the four

structural elements of the innovation system, previously outlined, influence the presence and performance of these functions. This is discussed further in Study 3.

Table 1.2 Title and explanation of the seven functions of an innovation system.

	Function title **Wieczorek and Hekkert (2012)**	**Function explanation** **Hekkert et al. (2007)**
1	Entrepreneurial activities	The presence of active entrepreneurs
2	Knowledge development	The presence of mechanisms for learning such as R&D investment, R&D projects and patents
3	Knowledge diffusion	The presence of networks facilitating knowledge exchange
4	Guidance of search	Activities that have an effect on demand for new knowledge and stimulation of knowledge development
5	Market formation	Creation of space for new knowledge using niche markets, supporting competitive advantage or quotas
6	Mobilisation of resources	Availability of sufficient human and financial resources
7	Creation of legitimacy	Activities such as lobbying to help the incorporation of new knowledge into existing incumbents' regime or destruct existing regimes

Source: Adapted from Wieczorek and Hekkert (2012) and Hekkert et al. (2007).

This thesis does not rely on any one conceptualisation of an innovation system. It is evident that innovation system scholars apply the interpretation that best suits their specific research needs. This is the approach applied in this thesis.

In Study 2, the Irish dairy innovation system is conceptualised as an infrastructure. Within this a problem focused innovation system, CellCheck, emerges to address a specific problem in the dairy value chain, that of milk quality. This problem focused innovation system is conceptualised as a process as the actors self-organise around the problem to formulate the innovation system. The findings from the study on the activities of part time innovation brokers in the context of a problem focused innovation system contribute to the process conceptualisation on the role of an innovation brokerage function in a self-organising entity.

In Study 3, the Irish agri-food sector is conceptualised as a set of functions. This informs the systemic policy framework used to examine two systemic instruments in the Irish agri-food sector. The findings from the study confirm a mediator role to facilitate collective action to bring about change in the structural elements of an existing innovation system. These activities support the process conceptualisation of an innovation system. In the next section, the specific areas within the innovation systems literature focused on in this research are introduced and discussed.

1.3.6 The Innovation Systems Problem

Hall (2007, p24) advocates that the core challenge to strengthening the innovation systems approach is to find ways to 1) build the right connections between actors, and 2) organise the different types of interactions needed at different levels of the innovation system. The research undertaken in this thesis in Study 2 and 3 contributes theoretical, empirical and policy related knowledge on addressing these challenges to strengthen the innovation systems approach. The general theory of innovation systems and specific concepts of problem focused innovation, systemic instruments, and innovation brokers inform the research questions posed and the approach taken. In this section, the concepts are outlined and discussed in relation to why they are used in this research. Next, they are compared for similarities and differences.

Problem Focused Innovation

Similar to the work of Sabel and Zeitlin (2012; 2008) on experimental networks, a new subject area in the innovation system literature is problem focused innovation systems. Comprising of a network of multi-disciplinary actors they emerge to collectively address market problems through knowledge development, diffusion and use. The concept was developed in Metcalfe and Ramlogan (2008) as an approach to organising activities to resolve market problems and improve the performance of developing economies and was developed further by Anandajayasekeram and Gebremedhin (2009) where it was used to inform the types of actors and interactions needed to address a problem in an agricultural value chain within a developing economy. As shown in Figure 1.2, value chains are embedded within innovation systems (Anandajayasekeram and Gebremedhin 2009; Metcalfe and Ramlogan 2008). The World Bank (2006, p21) defines a value chain as '*the set of interconnected, value creating activities undertaken by an enterprise to develop, produce, deliver and service a product or group*'.

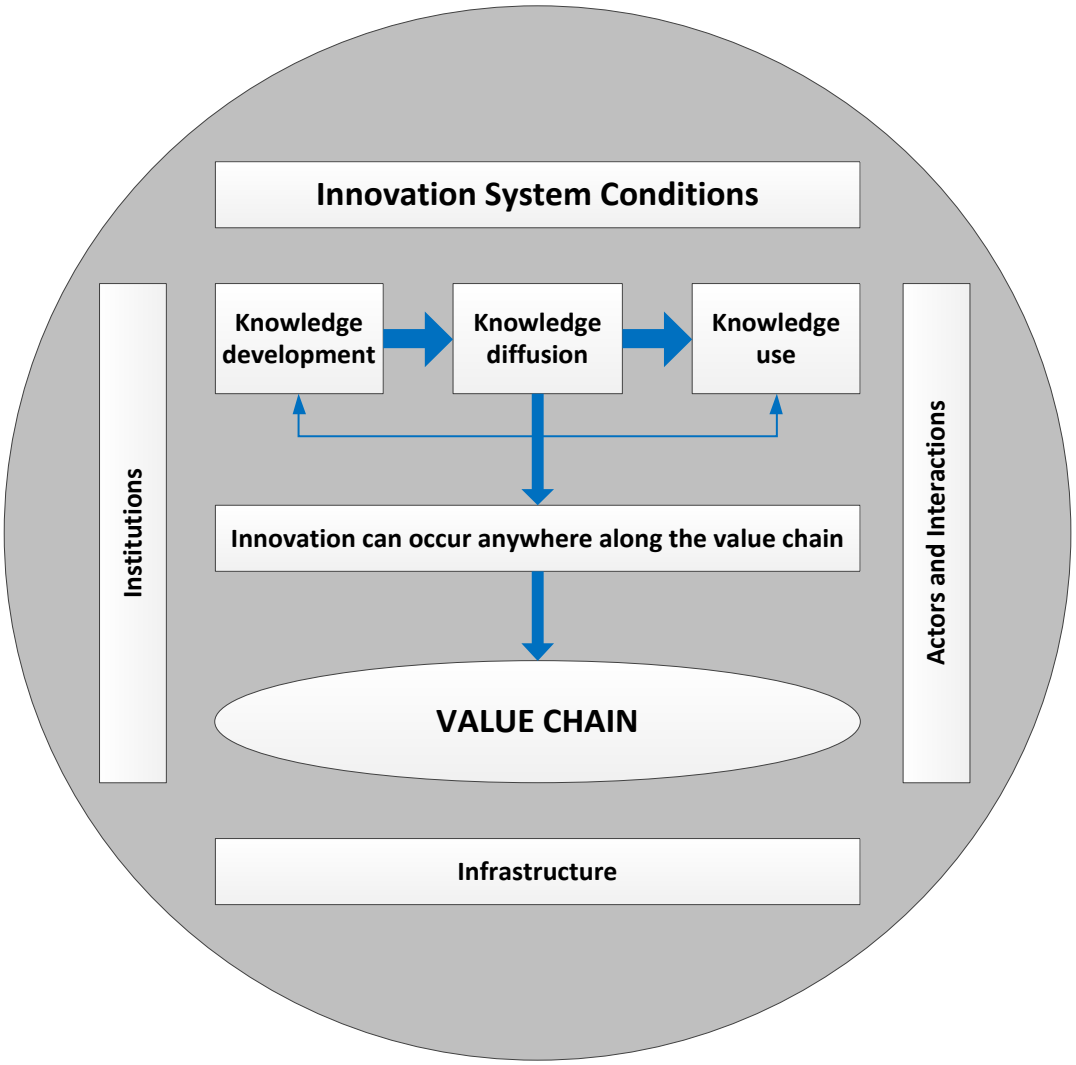

Figure 1.2 Value chains embedded within an innovation system
Source: Adapted from Anandajayasekeram and Gebremedhin (2009)

The system is constructed around the value chain problem (Anandajayasekeram and Gebremedhin 2009). A problem can occur in supply, demand and/or marketing stages of a value chain. The goal of the system is to address the problem by supporting innovation activities namely knowledge development, diffusion and use (Anandajayasekeram and Gebremedhin 2009; Metcalfe and Ramlogan 2008). The development of a problem focused innovation system is illustrated in Figure 1.3.

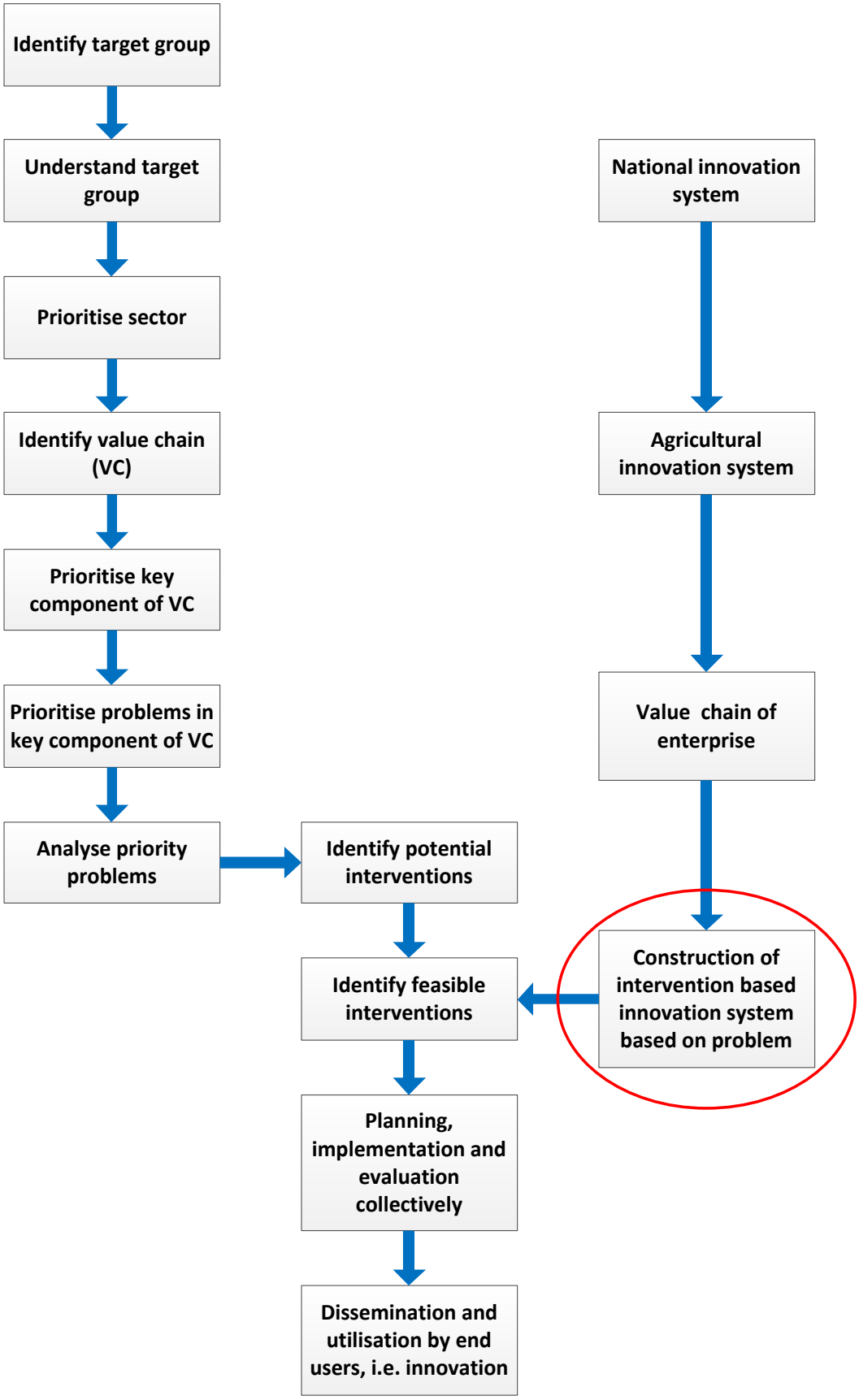

Figure 1.3 Development of a problem focused innovation system

Source: Adapted from Anandajayasekeram and Gebremedhin (2009)

The problem focused innovation system is a system process and shares a similarity with the experimental networks discussed in Sabel and Zeitlin (2012; 2008) in that the organisational form is not a top down, command and control structure nor does it take place spontaneously through an independent initiative but arises from problems that cannot be solved by established knowledge and actors share uncertainty on how to resolve them.

The boundaries of the system can be overlapping and unclear (Sabel and Zeitlin 2012; 2008). such that they can be situated within a sectoral innovation system[8] or across system boundaries such as national and/or sectoral innovation systems i.e. the system is trans-boundary (Metcalfe and Ramlogan 2008). Actors in the '*innovation ecology'* self-organise around the problem sequence to form the problem focused innovation system (Metcalfe and Ramlogan 2008). Principal actors in an ecology include firms, knowledge based consultancies, universities and public and private research organisations (Metcalfe and Ramlogan 2008). Figure 1.4 illustrates the construction of a problem focused innovation system drawing on the innovation ecology. As the problem sequence evolves, actors in the system as well as the connections between them vary (Anandajayasekeram and Gebremedhin 2009; Metcalfe and Ramlogan 2008). Furthermore, the problem focused innovation system is temporary in nature; once the problem is resolved the associated innovation system is dissolved.

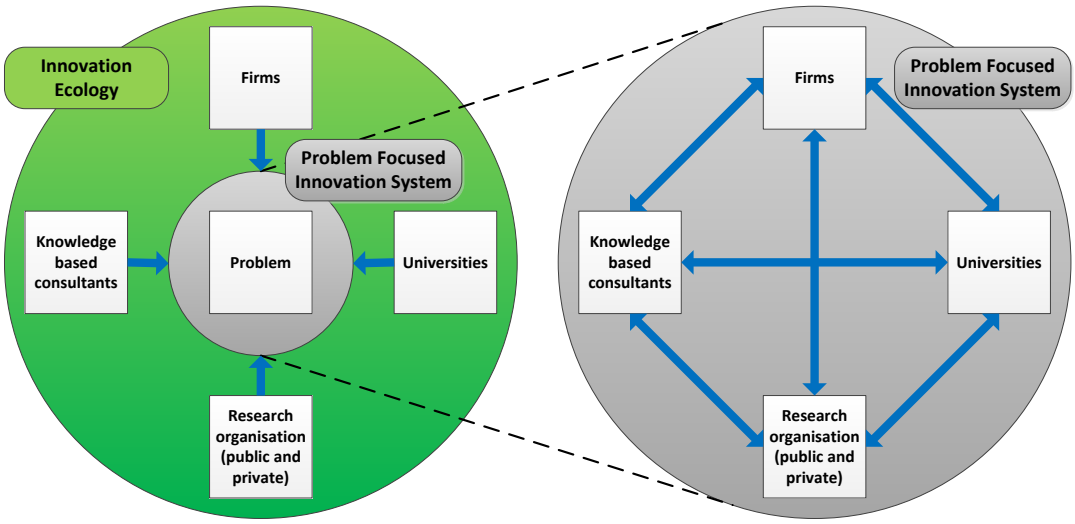

Figure 1.4 Constructing a problem focused innovation system

Source: Author's own adapted from Metcalfe and Ramlogan (2008)

[8] A sectoral innovation system (or sectoral system of innovation) is a group of actors carrying out market and non-market interactions for the creation, production and sale of sectoral products (Malerba 2006).

The problem focused innovation system approach is used in Study 2 to address the two challenges Hall (2007) outlines:

- To define the different types of interactions needed at different levels of the innovation system for problem solving
- To identify actors and connections needed

Problem focused innovation is a networked activity between multi-disciplinary actors. Knowledge exchange between actors is fundamental to the performance of these networks which is threatened by the different practices, priorities and institutional backgrounds of network actors (Batterink et al. 2010). Although these actors share the common goal of resolving a specific problem, coordinated interaction between the actors is difficult to achieve due to the opportunistic behaviour of actors and other missing factors namely trust, incentive, capacity and rules (Ekboir and Rajalahti 2012; Klerkx and Gildemacher 2012; Metcalfe and Ramlogan, 2008). Ekboir and Rajalahti (2012, p15) emphasise that effective coordination of individual's actions requires the following:

- A committed and capable leadership
- Appropriate incentives
- An enabling environment, in which important stakeholders that coordinate their activities have the mandate, culture, and freedom to participate
- Stable support programs
- Efforts to strengthen the capabilities for innovation and collective action
- Adaptation of public organisations.

Brokerage

Individuals or organisations with the commercial goal of building and maintaining linkages between disconnected actors in a network for innovation are referred to as '*innovation brokers'* (Madzudzo 2011; Klerkx and Leeuwis 2009b; Winch and Courtney 2007). As previously stated, innovation brokering is an alternative framework to building connections between different actor groups to the work of Burt (2007; 2004) and Lomas (2007) on information brokering across structural holes. More precisely, from an innovation systems perspective, a broader range of brokering tasks is needed than that of information or knowledge brokering to support coordinated action in networks (Fisher 2011; Klerkx et al. 2012). The function of innovation brokering which encompasses both information and knowledge brokering functions focuses on rearranging all technical, social and institutional relationships needed for innovation and change (Fisher 2011). The boundaries between the various brokering and intermediary roles are overlapping as illustrated in Figure 1.5.

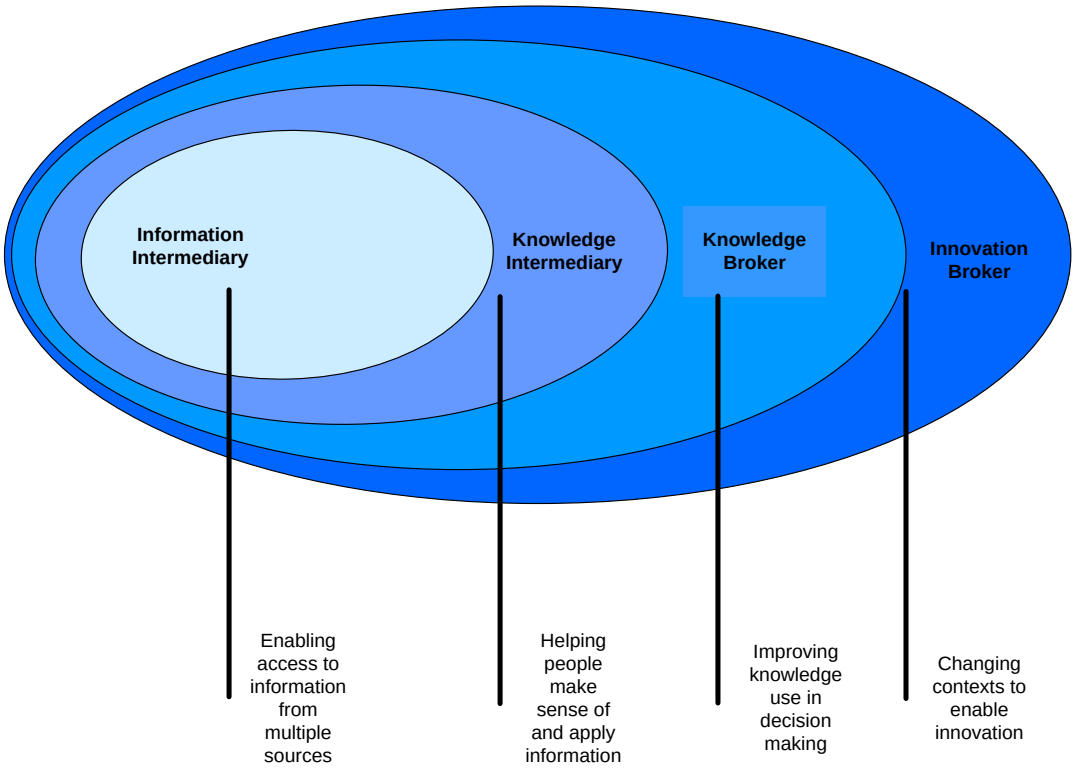

Figure 1.5 Nested set of different brokering and intermediary roles
Source: Fisher (2011, p3)

The functions of an innovation broker centre on articulating the needs of the actors, building and maintaining networks, and managing the on-going process of innovation (Batterink et al. 2010; Klerkx and Leeuwis 2009a). As a type of innovation intermediary it is differentiated from traditional intermediaries who are characterised as knowledge transfer agents concerned with building bilateral relations between actors and providing management support to individual companies(van Lente et al. 2003). Howells (2006, p720) defines an innovation intermediary as "*an organisation or body that acts as an agent or broker in any aspect of the innovation process between two or more parties*". Van Lente et al. (2003, p249) positions an innovation intermediary as an independent actor within an innovation system (Figure 1.6). Howells (2006) outlines the following ten functions for an innovation intermediary: foresight and diagnostics; scanning and information processing; knowledge processing and combination or recombination; gate keeping and brokering; testing and validation; accreditation; validation and regulation; protecting the results; commercialisation; evaluation of outcomes. The role of an innovation broker is narrower that that defined for innovation intermediaries by Howell (2006) and that of other knowledge actors (Fisher 2011). Innovation brokers do not directly engage in innovation activity (defined as knowledge generation, diffusion and use) but support innovation from an independent third party position (Klerkx and

Leeuwis 2009a; Winch and Courtney 2007). In addition, they so not seek to broker knowledge produced by them or by an organisation whom they are affiliated with (Fisher 2011).

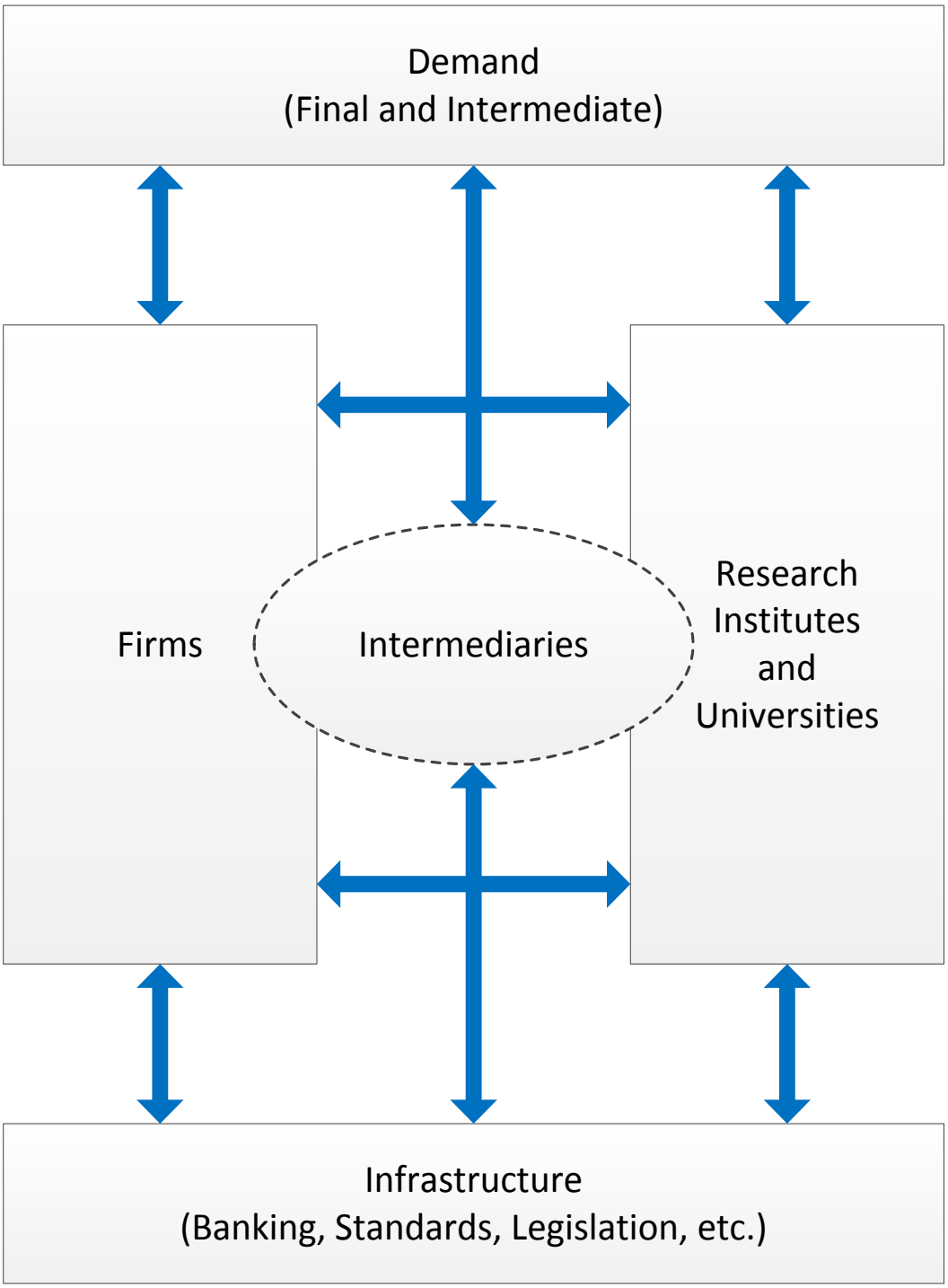

Figure 1.6 Structural position of an intermediary in an innovation system
Source: Van Lente et al. (2003, p249)

Based on the review of the literature, Figure 1.7 illustrates the author's view of the position of an innovation broker in a problem focused network. The innovation brokering

approach to building connections between multi-disciplinary actors to address structural holes in the problem focused network is the conceptual approach applied in Study 2.

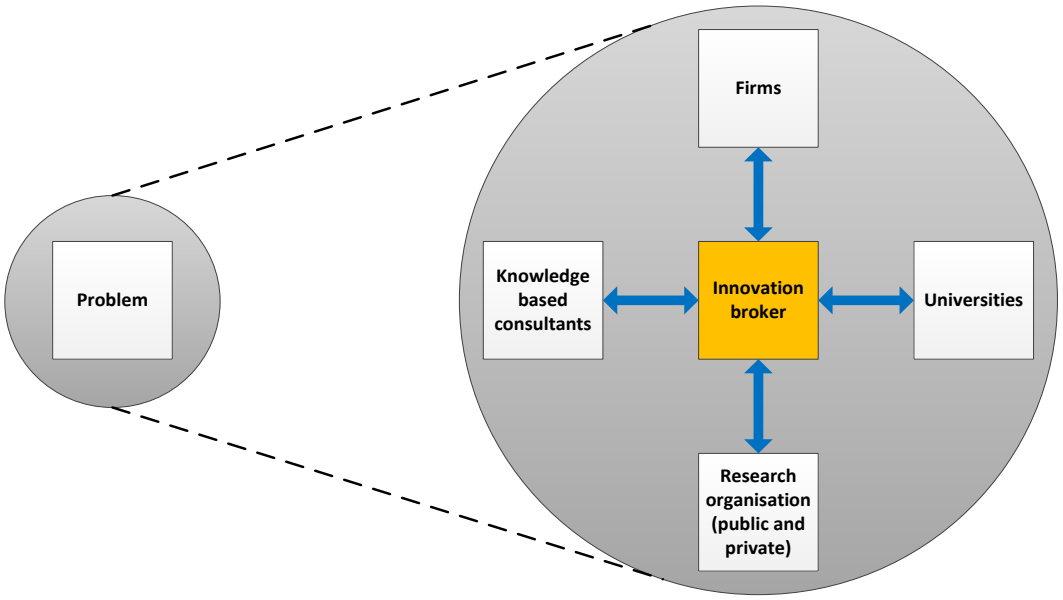

Figure 1.7 Positioning an innovation broker in a problem focused network

Systemic Instruments

Innovation requires efforts to change relationships and the institutional and infrastructural framework at different levels of the innovation system. This moves beyond the focus on research and its users and producers (Klerkx et al. 2012 and World Bank 2006). System instruments are mechanisms integrated to address a problem at the system level. Based on the rationale of systemic failure, the concept emerged as an alternative justification and policy intervention to the market failure approach (Bleda and del Ríob 2013; Klein Woolthuis, Lankhuizen and Gilsing 2005). Using the innovation systems approach, systemic policy frameworks have recently emerged notably in Klein Woolthuis, Lankhuizen and Gilsing (2005) and Wieczorek and Hekkert (2012) to guide the design and implementation of systemic instruments. Systemic policy objectives guide the design and implementation of systemic instruments. A systemic policy is a statement of intent for system wide change (Van Mierlo et al. 2010). Few empirical tests have been carried out to determine their feasibility for use in policy making to analyse innovation problems and formulate interventions.

What are the similarities and differences between a problem focused innovation system and a systemic instrument?

Problem focused innovation systems and systemic instruments are two types of interventions to improving innovation in the context of an innovation system. The

interventions reflect the non-linear, systemic, and uncertain nature of the innovation process as opposed to innovation as a linear process. They are orchestrated to address specific problems occurring in system, network or interactive processes within the innovation system. The activities of the interventions, undertaken by a multi-actor configuration purposefully working to resolve the problem, focus on directing knowledge flows at the problem. The choice of intervention and their individual design is influenced by the characteristics of the system problem it aims to address.

Similar to the overlapping nature of the three dynamic processes of system, networks and interactions within an innovation system, the two concepts do overlap as shown in Figure 1.8. For example, although a problem focused innovation system is implemented to address a value chain problem, a so called system problem a systemic instrument may be required. This is to address weak or missing structural element or function within the newly formed problem focused innovation system. This is evident in Study 2. Weak levels of interaction between network actors were identified in the empirical context of Study 2. This relates to a problem in the structural element of interactions within the innovation system. Using the concept of a systemic instrument, an innovation broker is a type of systemic instrument used to stimulate interactions between the actors. Therefore, the systemic instrument literature extends the problem focused innovation system literature by, providing a guide to policy makers and researchers on diagnosing problems and implementing solutions within the associated system.

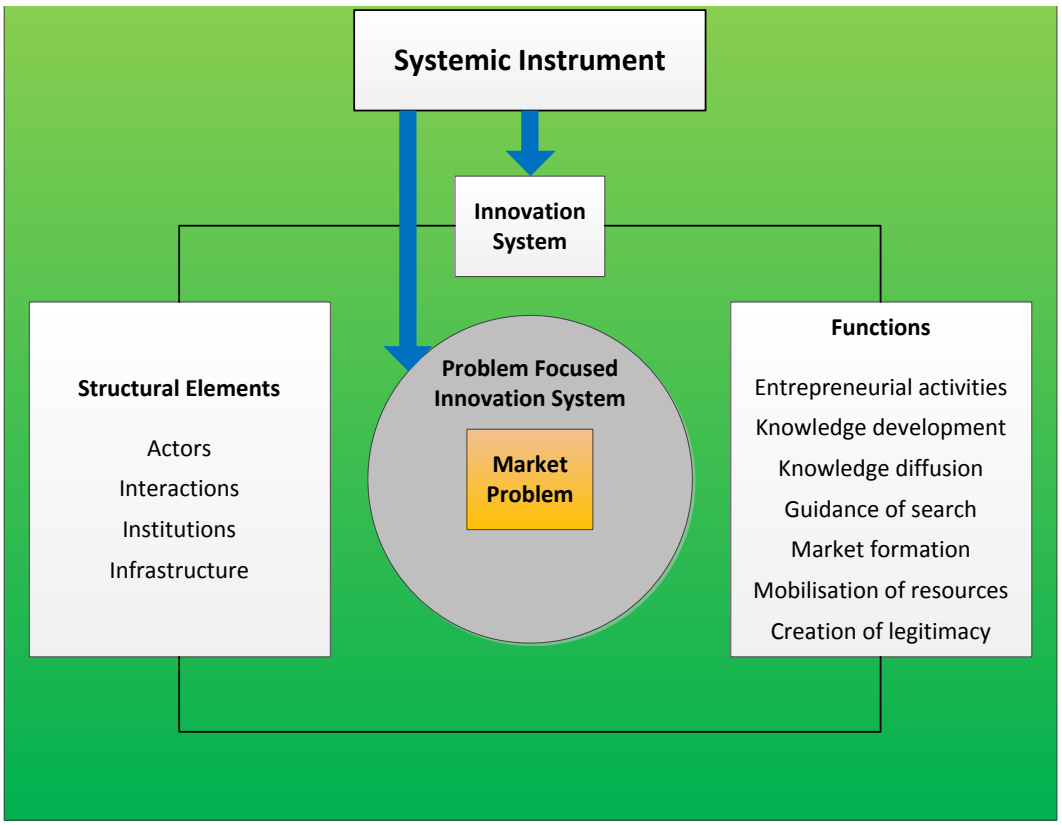

Figure 1.8 Linking the problem focused innovation system concept and the systemic instrument concept

The interventions differ based on the alternative levels of an innovation system at which they operate. There are multiple levels of an innovation system. Ekboir and Rajalahti (2012) differentiates the levels as macro (e.g. national), meso (e.g. regional or sectoral) or micro (e.g. farmer or individual). A problem focused innovation system is an innovation system positioned within an existing innovation system. It is purposefully constructed around a value chain problem. A systemic instrument is purposefully constructed to address weak or missing elements within an innovation system. The elements comprise of structural components and functions. The intervention required depends on the level at which the problem can be resolved. For example, an improvement in milk quality, a dairy value chain problem, requires problem solving activities that target milk producers (farmers). On the other hand, sustainable food production in the Irish agri-food sector requires problem solving activities that target all agri-food producers (including farmers and food manufacturers).

In a contribution to the theory on problem focused innovation systems, this thesis extends the concept in two ways, First, an innovation brokerage function is a mechanism to address the '*coordination problem'* identified in Metcalfe and Ramlogan (2008). Second, the systemic policy framework provides a guide, for policy makers and researchers, to

identify appropriate tools to achieve systemic instrument goals. The empirical context for the research undertaken in this thesis is the Irish dairy industry. In the next section, this empirical setting is discussed.

1.4 The Empirical Setting

The empirical setting for the research is the Irish dairy industry. More specifically, Study 1 and Study 2 focus on innovation-based activity developed and implemented by direct and indirect participants, in the context of the dairy value chain. Study 3 focuses on innovation support activity in the context of the agri-food industry. In this section, the Irish dairy industry is discussed.

Milk Production

There are approximately 18,000 dairy farms in Ireland (Central Statistics Office 2012a) which produce 90% of all milk processed in Ireland (Central Statistics Office 2011b). Table 1.3 shows the total milk supplies processed in Ireland in 2011 and 2012. The reduction in domestic milk supplies over the two years may reflect producers' efforts to avoid the super levy associated with the EU milk quota and/or to reduce production costs. The milk produced is used for two purposes: liquid milk for human consumption and manufacturing milk used to produce products.

Table 1.3 Milk intake by creameries and pasteurisers (million litres)

Category	2011	2012
Domestic milk supplies	5,377	5,224.6
Import milk supplies*	356.1	405.7
Total milk supplies	5,733.1	5,630.3

*Denotes raw milk imports and excludes imported packaged milk for retail sale

Source: CSO Milk Statistics (2013)

Dairy Processing

Raw milk consists of milk solids namely water (87.8%), lactose (4.7%), butterfat (3.5%), protein (3.2%) and minerals (0.8%) (Agri-Aware 2013). Milk processing involves the separation and concentration of these solids to produce milk for human consumption and dairy products.

The processing sector is highly fragmented with 33 dairy processing plants in Ireland (Irish Dairy Industries Association 2007). Six companies process 80% of milk produced (Geraghty 2011). They are Glanbia, Kerry Group, Dairygold, Carbery Foods, Lakeland Dairies and Tipperary Co-op. Other major processors include Arrabawn and Connacht Gold. Furthermore, the sector is characterised by a mixture of cooperatives some small some large and some with public limited company (PLC) holdings (Briscoe and Ward 2006). Over recent years some consolidation has occurred in the sector through mergers

and acquisitions (Briscoe and Ward 2006). A number of dairy cooperatives no longer process milk but continue to operate collection services for other processors.

Liquid milk is processed[9] and sold for human consumption in the domestic market. This accounts for approximately 9% of all milk processed in Ireland in 2012 (Table 1.4). The remaining 91% of milk supplies are processed into products. Manufacturing milk is processed into products mainly butter, cheese, powdered dairy products[10], casein, whey, infant foods and fresh milk produce. There are 22 manufacturing milk plant locations in Ireland (Figure 1.9). In terms of products, there are 13 milk powder plants, nine butter plants, eight cheese plants and four infant food plants (Irish Cooperative Organisation Society 2014).

Table 1.4 Percentage of annual milk supplies

	2011	**2012**
Milk sold for human consumption	8.61%	8.64%
Milk for food production	91.3%	91.36%

Source: CSO Milk Statistics (2013)

[9] This is a three step process: milk separation; homogenisation and pasteurisation.

[10] Powdered milk products refer to whole milk powder and skimmed milk powder and not infant milk formula. Powdered dairy products are produced by eliminating the water from the product. Skimmed milk powder is an ingredient in infant milk formula.

Figure 1.9 The location of manufacturing milk plants in Ireland
Source: Irish Co-operative Organisations Society website (January 2014)

Sales and Marketing

In the domestic market, the dairy co-operatives/PLCs market and sell their products. The National Dairy Council, funded by the farmer levy on milk price per litre, is responsible for the marketing of milk and dairy products in the domestic market. Ireland has a small domestic population relative to its milk production contributing to the high percentage (85%) of dairy products produced in Ireland being exported (Department of Agriculture Fisheries and Food 2010c).

The sales and marketing of Irish dairy products in export markets is principally undertaken by four dairy companies namely Irish Dairy Board, Glanbia PLC, Dairygold Co-operative, and Kerry Group (Dobson 2007). The Irish Dairy Board (IDB) accounts for 50% of dairy products exported (Geraghty 2011), an example of a cooperative alliance between Irish dairy processors (Clancy et al. 2001). The IDB packages and markets Irish dairy products under several brands including Kerrygold and Pilgrim Choice. It is structured as a commercial co-operative with responsibility for marketing the Irish dairy

products of its members, the Irish co-operatives/PLCs, on export markets. Therefore, in some markets, IDB and the larger co-operatives/PLCs are directly competing.

1.4.1 Strategic Objective of the Irish dairy industry

The products produced by the Irish sector can be differentiated between commodity and 'value added'. Commodity products are undifferentiated products and include bulk cheese, skim milk powder, whole milk powder, cheese and casein (Babcock Institute Country Study Team 2007). Value added products are defined as products that have increased in value due to processing. They include infant milk formula, cheese, butter, cream liquor and confectionary. Industry reports and reviews emphasise the need to shift production to 'value added products' to sustain long term competitiveness (Food and Drink Industry Ireland 2013; Bell and Shelman 2010; Department of Agriculture Fisheries and Food 2010a; Prospectus and Promar 2003). Value added products receive higher margins arise from unique differentiated products, controlled brands, scarcity in supply and addressing the needs of consumers and customers.

The Irish dairy industry has had and continues to have a strong dependency on commodity products. In 2010, approximately two thirds of Irish exports were priced at world base commodity price level (Department of Agriculture Fisheries and Food 2010b). These are undifferentiated product types and include products such as bulk cheese, skim milk powder, whole milk powder, cheese and casein (Babcock Institute Country Study Team 2007). Dobson (2007) outlines the following two conditions as influencing the production of commodity prices:

- Limited domestic milk supplies due to EU quota restrictions and seasonality of the milk production
- European Union market intervention supports (export refunds, private storage aid[11] and intervention buying for butter and skimmed milk powder).

Commodity products are vulnerable to strong market competition and lower prices at times of oversupply (O'Keeffe 2010). Profits arise from economies of scale and up to 2008 from EU market supports, such as export refunds and intervention buying (for butter and skimmed milk powder), under the Common Agricultural Policy[12] (CAP) (Prospectus and Promar 2003). CAP supported basic dairy products such as cheese and butter. It

[11] Private storage aid was a measure introduced by the EU to subsidise storage of cheese and butter products when seasonal imbalance arose between supply and demand in the product markets. Since CAP 'Health Check' reform in 2008 the scheme only operates to subsidise temporary storage of butter and contracts are granted through application to the Department of Agriculture, Food and Marine.

[12] CAP is the common EU policy that supports EU agricultural production. It traditionally comprised of a system of subsidies and support programmes for agriculture.

protected EU producers from world price fluctuations through the use of import duties and export refunds (also referred to as export subsidies).

The removal of market supports, during the CAP reform in 2008, increased the need for manufacturers to shift their production focus onto value added products and ingredients. These types of products which include ingredients are differentiated from basic products such as butter and cheese. They receive higher prices and have higher margins than commodity products. The success of Irish dairy companies Kerry Group and Glanbia has been based on production of high value ingredients such as specialist milk powder to improve the nutritional and protein content of other foods and beverages. These types of products and ingredients address current and emerging consumer demands and are tailored to specific markets. Differentiated product types receive higher margins than commodity products returning greater profits.

Technical innovation is paramount to the production of value added products to ensure the sustainability of the industry (Dillon et al. 2008). To support the production and commercialisation of value added products the Irish Government has financially supported the following two initiatives:

- The Dairy Investment Fund[13] to improve processing facilitates in Ireland (Department of Agriculture Fisheries and Food 2010b)
- The Dairy Innovation Centre[14] to support the development, commercialisation and marketing of new value added dairy products.

Ireland's most significant value added product

Ireland's most significant type of value added product is infant milk formula. Ireland produces approximately 15% of the World's supply of infant milk formula (Forfas 2013). Furthermore, demand in the Asia is growing year on year. Customers in Asian markets are willing to pay a higher premium for imported products as they are perceived as of higher quality and produced under food safety standards (Irish Farmers Journal and KPMG 2013). Branded infant milk formula products produced in Ireland include Cow&Gate, Aptimal, Similac and Gain. Three of the five largest global manufacturers are located in Ireland: Nestlé, Danone and Abbott. Danone is largest manufacturer of infant milk formula in both Ireland and Europe (Ketch 2012).

[13] The Fund provided grant assistance of over €114million over the period 2007-2010 and supported 19 capital investment projects in the processing sector.

[14] This is a market led collaborative development programme between the Irish Dairy Board and Teagasc.

There are three infant nutrition companies operating four processing plants in Ireland: Danone, Nestlé and Abbott. Danone is the largest producer of infant milk formula operating two plants in Ireland in Cork and Wexford. The Macroom plant produces a 'semi-finished' powder which is distributed to the packaging plant in Wexford and other afflated plants across Europe. The Wexford plant produces the Cow & Gate, Aptamil, Nutrilon and Bebilon product ranges for the Irish, British, Dutch, Belgian, Spanish, Portuguese and Polish markets. The Macroom plant sources 60% of its ingredients from the Irish dairy industry. The ingredients include fresh milk and other dairy products such as skim milk powder, demineralised whey, lactose and whey protein sourced mainly through Dairygold Cooperative but also Lakelands Dairies, Glanbia Cooperative and Kerry Cooperative (Ketch 2012).

Nestlé operates one infant milk formula plant in Ireland located in Askeaton, Co Limerick. The plant was opened in 1974 and was formerly owned by Pfizer. The plant produces over 48,000 tonnes of powder infant formula annually and is one of the world's largest infant formula sites. It sources 70% skimmed milk powder and 75% lactose requirements from Ireland mainly from Glanbia, Lakeland, Kerry and Dairygold. Since, the acquisition of the Askeaton plant, Nestlé has become the largest global producer of infant milk formula, followed by Mead Johnson and Danone (Leslie 2012). Nestlé has a second infant formula company which is located in Germany. Nestlé's brands include Nan, Gerber and Lactogen and those formerly owned by Pfizer S-26 Gold, SMA and Promil. Nestlé sells infant foods in Saudi Arabia, South Africa, Chile, Philippines, Mexico, Hong Kong, Venezuela, Colombia and Egypt.

Abbott Nutrition operates an infant formulae manufacturing plant in Cootehill, Co Cavan. This plant was established in 1975 and is the largest production facility for infant formulae within the global Abbott Corporation. The plant produces a range of infant formulae under the brand Similac and a follow on milk under the brand Gain. The main ingredient is liquid skim milk. The milk supplies are sourced directly from approximately 1,000 farmers, processing approximately 500,000 litres a day. Based on the 2012 milk supplies listed in Table 1.3 above, Abbott Nutrition processes approximately 3.2% of all milk processed in Ireland (includes domestic and imported supplies). The skim milk is combined with carbohydrate, vegetable oils, vitamins and minerals. The product is blended, pasteurised, dried and packaged at the Cootehill plant. This product is exported to markets such as Europe, South America, East Asia, the Middle East, Latin America and Canada.

1.5 Research Design

This thesis explores innovation in the context of the Irish dairy industry. The research is about understanding, exploring and explaining innovation as a socio-economic phenomenon. More specifically, it is about measuring (Study 1), orchestrating (Study 2), and designing (Study 3) policy towards innovation. The research used a variety of methods and sources to examine and explore these dimensions of innovation, and these are explained in this section. There are three elements of a social science research design: philosophical assumptions, research methodologies and research methods (Creswell 2009). The set of philosophical assumptions guiding the social science research is called a paradigm, a term coined by Thomas Kuhn in *The Structure of Scientific Revolutions* (1962). The chosen philosophical approach in this thesis is that of pragmatic realism. The second element in the framework, research methodology, is the approach to the inquiry: qualitative, quantitative or a combination of both. The choice of methodology is informed by the researchers' ontological and epistemological stance (Guba and Lincoln 2005;Holden and Lynch 2004; Guba and Lincoln 1994). The third element in the framework, research methods involved the forms of data collection, analysis and interpretations proposed for the studies.

1.5.1 Philosophical Assumptions

The social phenomena studied in this thesis are international product markets, innovation brokers and systemic instruments. All of these phenomena are constricted and influenced by actors within the innovation system.

The philosophical approach taken in this research is pragmatic realism. Pragmatism is derived from the work of Charles S. Peirce, William James and John Dewey (Cherryholmes 1992). Instead of focusing on methodology, pragmatist researchers are concerned with the problem and they permit the use of a variety of methods and approaches available to understand the problem. From this standpoint, researchers do not commit the research inquiry to any one philosophical paradigm. Pragmatic realism was developed by Hilary Putnam (Sosa 1993). From an ontological standpoint, pragmatic realists assume that reality exists. Pragmatism permits the use of unobservables in research and theory, which comes from the ontology of realism, which differs from the positivists' exclusive use of observables (Creswell 2009). For pragmatic realists, there exists a dynamic world with one objective reality.

This research seeks to answer three distinct questions relating to innovation. From the philosophical assumption of pragmatic realism, the focus is on the problem rather than

the theory or methods (Creswell 2009). It is possible to generate knowledge about and evidence for each of the social phenomena. Study 1 measures innovation performance using trade data. It is assumed here that the product market as a social unit has a reality that is independent of individuals and organisations who are members of it. The performance of the products in the market is knowable through the use of trade data. Innovation brokers and systemic instruments studied in Study 2 and Study 3 respectively are real in that they are constructed ideas that are continually reviewed and reworked by those involved in them through social interaction and reflection. Study 2 focuses on the activities and practices of individuals. The knowledge can be made known through interviews, observations and document analysis. Study 3 focuses on the design and implementation of systemic instruments. This knowledge can be made knowable through the experiences of instrument coordinators. Therefore, the ontological assumption across all three studies is realism. Where the studies differ, is in their epistemological assumptions – the relationship between the '*knower*' and the '*known*'. Study 1 takes a positivist approach. Knowledge of the social phenomena is objectively measured and recorded rather than subjective understandings. The researcher is independent of the quantitative data collected which is used to measure and hypothesise around causes of innovation performance.

Study 2 and 3 take an interpretivist approach that generates knowledge from the subjective understandings of the innovation actors to explain the social phenomenon of innovation brokering and systemic instruments. Qualitative data, rich in detail and description is collected to uncover and work with subjective meanings, interpret meaning within a specific context. Collecting qualitative data to explore and interpret the experiences of the individuals in terms of the relevant literatures and concepts of innovation brokering and systemic instruments (Matthews and Ross 2010).

1.5.2 Methodology

The research is informed by the philosophical assumption of pragmatic realism. Study 1 uses an economic model that comprises measures of unit value and market share derived from trade data, to measure the relative innovation performance. In contrast, the research methodology in study 2 and 3 is that of the case study. More specifically, the case study approach is employed to explore the activities of part time innovation brokers and systemic instruments to enhance the innovative capacity of agri-food stakeholders. This research strategy of the case study is discussed in detail in this section.

Yin (1994) defines a case study as a methodological choice, differentiated from a qualitative or quantitative research strategy, it encompasses a method that informs the research design and approaches to data collection and analysis. The inquiry relies on multiple sources of evidence which can be a mixture of qualitative and quantitative.

Case studies are used in social science research for explanatory, exploratory and descriptive purposes. They allow the researcher collect detailed information, on entities such as individuals, programmes, processes and experiences using a variety of methods over period of time. The choice of research strategy depends on the research question posed; the extent of control the researcher has over the event and on contemporary as opposed to historical nature of the event (Yin 1994). Yin (1994) suggests that other research strategies such as surveys, experiments and histories may also be used for explanatory, exploratory and descriptive purposes. Case studies are used to address '*how*' or '*why*' research questions, when the researcher has minimal control over events and the focus is on contemporary as opposed to historical phenomenon in a real life setting

There are four criteria used for assessing the quality of social science methods: construct validity, internal validity, reliability, and external validity. Yin (1994) outlines various tactics in designing and doing case studies to address these criteria. Construct validity refers to establishing correct operational measures for concepts being studied. This criterion can be problematic in case study research (Bryman 2008; Yin 1994). Yin (1994) suggests use of multiple sources of evidence and recording the chain of evidence in data collection and having informants review final report. Internal validity refers to whether a researcher(s) observations match theoretical ideas developed. This is a concern for explanatory and casual studies only and is addressed by data analysis procedures such as pattern-matching which involves linking several pieces of information from the same case to a theoretical proposition (Yin 1994). The third criterion, reliability refers to the degree to which the same study can be replicated by another investigator. This requires documenting the research procedures.

The final criterion, external validity, is the most problematic for case study research (Bryman 2008; Yin 1994). The criterion refers to the degree to which research findings can be generalised to social settings. It relates to whether the case study findings are generalisable beyond the case. The generalisability of case study findings are particularly criticised on the belief that the evidence they present is limited. However, the aim of case study research is to not to generalise to populations as in the case of survey research but to generalise to theory (Bryman 2008). Flyvbjerg (2006) outlines this as one of the five misunderstandings of case study research.

In particular, critics state that single case study designs are poor for generalising to other cases or populations, but, Yin (1994) emphasises that critics are contrasting the situation to survey research. Case study findings are used to generalise to existing theory for theory building. Yin (1994) refers to this process as 'analytical generalisation' as opposed to 'statistical generalisation' used in survey research. Analytical generalisation refers to generalising a particular set of results to some broader theory. The existing theory plays an important role in analytical generalisation as it is the level to which the results are generalised to (i.e. the previously developed theory acts as a template to compare empirical findings).

In addition to the criticism that one cannot generalise the findings from a single case study, Flyvbjerg (2006) outlines and refutes four other criticisms of case study research. The first view that general, context independent so called theoretical knowledge is more valuable than context dependent knowledge is refuted based on the inability to find predictive theories in the study of humans. The second view that the cases study method is more valuable for generating hypothesis for research than for hypothesis testing and theory building stems from the misunderstanding that one cannot generalise findings from single case study designs. From the standpoint that single case study findings are generalizable to theory, Flyvbjerg (2006) emphasises that the case study is useful for both theory building and theory testing and is therefore applicable for generating and testing hypotheses. The third misunderstanding is that cases studies contain a bias towards verification. Flyvbjerg (2006) contradicts the idea that case study research is less rigorous and subject to researcher bias with examples from a variety of researchers that end up dismissing preconceived ideas. The final misunderstanding is that it is difficult to summarise case studies into general propositions and theories. Flyvbjerg (2006) agrees but emphasises that it is not always useful to summarise case studies and generalise case studies. Narratives can contribute to the collective development of knowledge.

Case studies consist of either a single case or multiple case study design. For Yin (1994), the choice between a single or multiple case study is based on the research design as both are included in the case study strategy. A single case study design is used when the case is a critical, extreme/unique or revelatory case. The rationale of using a multiple case design is based on replication logic and not sampling. Multiple cases are viewed like multiple experiments with similar results or contrasting results predicted at beginning of the investigation. This design is used to aid the generation of theory from the case study evidence through building a general explanation that fits with each of the individual cases

(Eisenhardt 1989). Single and multiple case study designs may involve one or multiple units of analysis, which are referred to as holistic and embedded case studies respectively.

This thesis draws on the case study methodology in Study 2 and Study 3 to address the specific '*how*' questions developed from the innovation brokering and systemic instrument literatures. These questions centre on contemporary phenomena such as the establishment of innovation broker as coordinators of problem focused innovation and the implementation process of systemic instrument goals. These were both situations where the boundaries between the phenomenon and context were not clear, contextual information was important and multiple sources of evidence would be useful. In these situations, the research strategy of the case study was best suited to address the research questions. Study 2 is an embedded single case study design of the national mastitis control programme CellCheck, including interviews with seven innovation brokers. Study 3 draws on two single embedded case studies of systemic instruments in the empirical context of the Irish agri-food industry: Origin Green and Food for Health Ireland. Study 1, in contrast, addresses a '*what*' question, in relation to the relative innovation performance of Irish dairy products. An upgrading framework developed in the economic literature is applied. A variety of research and sources are used. In the next section, a brief overview of the methods employed in this thesis is given.

1.5.3 Methods

The research questions, each in a separate empirical study, address different aspects of innovation. Study 1 addresses innovation performance, Study 2 addresses innovation brokers and Study 3 addresses systemic instruments.

In Study 1, international trade data on Irish dairy exports and Irish dairy's global markets was collected. Using the data, measures of relative unit price and market share were calculated for Irish dairy products. The upgrading framework developed in Kaplinsky and Readman (2005) was applied to explain the relationship between the combined measures of unit price and market share and the relative innovation performance of Irish dairy products on global markets.

In Study 2 and 3, a variety of qualitative research methods are used. According to Polkinghorne (2005, p137) the role of these types of methods is to make use of '*languaged data*' (Polkinghorne 2005). The data collected is interrelated words spoken or written that are combined into sentences, which are in turn combined into discourses (Polkinghorne 2005).

Qualitative research requires describing, understanding and clarifying a human experience or situation (Polkinghorne 2005; Mason 1996). Participants and documents for a qualitative study are selected because they provide contributions to filling out the structure and character of the experience under investigation not because they fulfil statistical inference (Polkinghorne 2005). Each method used generates its own data. The methods used in this research included semi structured interviews, observations and document analysis. In the use of interviews the role of the interviewer is to ask, listen and interpret (Mason 1996) whereas the role of the interviewee is to recollect, reflect and communicate on their experiences (Polkinghorne 2005).

Given the sparse literature on part time innovation brokers and systemic instruments, an in-depth analysis, rich in contextual detail was required. In Study 2, qualitative data on the experiences of seven part time innovation brokers operating in the Irish dairy industry was collected. In Study 3, qualitative data on the design experiences of systemic instrument coordinators was collected.

1.6 Structure of the thesis

This thesis consists of three thematically homogeneous studies; the overarching theme being innovation in the Irish dairy industry. The first study, '*The Relative Innovation Performance of Irish Dairy Products on Global Markets*,' is presented in Chapter 2. The second study, '*Establishing Part Time Innovation Brokers in a Problem Focused Innovation System*,' is presented in Chapter 3. The third study, '*A Policy Approach to System Innovation: Systemic Instruments in the Irish Agri-Food Industry*,' is presented in Chapter 4. Conclusions for the thesis, including the main findings and contributions, are presented in Chapter 5 together with suggestions for future work.

2 The Relative Innovation Performance of Irish Dairy Products on Global Markets

2.1 Introduction

Over 85% of Irish dairy products are exported. Rising global demand for dairy products and the potential to increase milk output post abolition of European Union milk quotas in 2015, presents opportunities for the Irish dairy industry. Innovation can help deliver on these opportunities by improving the competitiveness of Irish dairy produce on global markets. Competitiveness on global markets relates to the capacity of a product to increase its share of the market at the expense of rivals. However, innovation may not improve the competitiveness if the rate of innovation is lower than that of competitors. No studies have assessed the innovation performance of Irish dairy product exports on global markets. Some studies however, have looked at the relative competitiveness (Dobson 2007; Prospectus and Promar 2003; Clancy et al. 2001) and sustainability (Dillon et al. 2008) of the Irish dairy industry.

In Kaplinsky and Readman (2005) a combination of import unit values and market shares are used to assess product, and to a lesser extent process innovation activity in the global furniture sector. The framework developed in Kaplinsky and Readman (2005) uses international trade data on unit value and market share as measures of innovation activity. The process of innovating at a rate faster than competitors (identified by changes in relative unit value and market share) reflects relative innovation performance, or *upgrading* as defined by Kaplinsky and Readman (2005). In this study, the framework is applied to assess the relative innovation performance of Irish dairy products on global markets over the time period 2000 to 2010 inclusive. Three particular dairy product groups are assessed: infant foods, cheese, and butter.

The study is structured as follows. In the following section the rationale for using the Kaplinksy and Readman (2005) framework to measure relative innovation performance is detailed. In section 2.3, an overview of the empirical setting - the Irish dairy industry -

with a specific focus on dairy exports is given. The methodology is outlined in section 2.4. This details the trade data used, the approach to empirical analysis and the opportunities and challenges to using trade data to measure innovation performance. Section 2.5 presents a descriptive analysis of the export data for each dairy product export. The results of the upgrading analysis are presented across sections 2.6, 2.7 and 2.8. Section 2.9 discusses the implications of the study's findings, the limitations of the analysis, the opportunities for future research, the contributions of the study and lastly the implications for policy. Section 2.10 concludes the study.

2.1.1 Measuring Innovation Performance

The Oslo Manual (2005, p5) defines innovation broadly as

'*the implementation of a new or significantly improved product (good or service), or process, or a new marketing method or a new organisational method in business practice, workplace or organisation or external relations*'.

The focus of this study is on product and process innovation. Therefore, innovation is defined as the introduction of a new or significantly improved good (or service) or production process. Furthermore, innovation can be either new to the market or new to the firm. Innovation activity is defined in the Oslo Manual (2005, p47) as

'*all scientific, technological, organisational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations*'.

There are two ways to measure innovation performance using trade data: unit value analysis and market share analysis (Priede 2013; Kaplinsky and Santos Paulino 2005; Aiginger 1997). Underpinning these two measures is a combination of price and non-price competition.

The first measure, the unit value of internationally traded goods, is used as an indicator of non-price competition, referred to hereafter as quality competition. The rationale for using it to measure innovation performance is that without innovation, or if barriers to entry are low, price competition drives producers out of production (Kaplinsky and Santos Paulino 2005). More specifically, those goods requiring relatively little innovative activities have a low unit value. In addition to market demand and price, the unit value of a product may also reflect changes in the quality of a product (Priede 2013). A change in quality can include a shift to value enhancing activities such as service, design or advertising. Unit value is defined as the gross value of exports or imports divided by the physical volume (Aiginger 1997).

The literature on unit values of traded products outlines a number of disadvantages to using unit value as a as an indicator of innovation performance (Priede 2013; Kaplinsky and Santos Paulino 2005; Aiginger 1997):

- The use of single point in time prices which fail to detect the dynamics of innovative activities
- Changes in unit value can be caused by changing exchange rates or input prices and not productivity performance
- Trade growth measured using high levels of aggregated data can include a combination of extensive (more trade of same product type) and intensive (more trade but differentiated products)
- Unit values may reflect a combination of quality and cost elements.

In addition to unit value, market shares have also been used widely as an indicator of trade performance, more specifically to assess international competitiveness on global markets (Montobbio and Rampa 2005; Narula and Wakelin 1998). However, a rise in market share can reflect two different situations. It can arise from product innovation and rising product values or from a reduction in relative costs and an increase in traded volumes (Kaplinsky and Readman 2005). For the second reason, the fall in relative costs can reflect process efficiency or a reduction in cost of living in the producer country. Kaplinsky and Readman (2005) emphasise that market share analysis may confuse the following three processes which affect the share of market value: a) product innovation and rising relative prices; b) falling prices arising from process innovation, falling costs and rising volumes; c) falling prices and rising volumes with static process innovation therefore declining returns from export markets.

Kaplinsky and Readman (2005) develop a new type of innovation measure by combining two existing metrics of innovation: relative unit value and market share. More specifically, the combined use of the metrics assesses the relative innovation performance of a product (good or service) relative to competitors using international trade statistics. The rationale outlined for combining the two metrics is that firms which engage in successful product innovation receive higher prices for their output. However, higher prices may also be indicative of inefficiencies in production which imply a reduction in innovation performance. Therefore, the market share metric is used as a measure of cost competitiveness.

The framework developed has two key assumptions. First, it assumes homogeneity of product thus requiring the use of high disaggregated levels of trade data. Secondly, costs

which influence the ability to sustain market shares are assumed to reflect process efficiency and not input costs. This second assumption allows Quadrant 4, in Table 2.1, represents process competitiveness.

Kaplinsky and Readman (2005) address the issues outlined above for using unit value and market share analysis in turn. To improve the unit value analysis the procedures undertaken are as follows. Firstly, the authors look at changes in unit value over time as opposed to prices at one point in. Unit value is calculated based on a two year moving average (TYMA) to eliminate year on year currency fluctuations. Secondly, as unit value may be influenced by changing exchange rates or input prices and not productivity performance, the exchange rates and input prices are assumed stable in the analysis. Thirdly, the highest level of disaggregation of global trade statistics are used to distinguish between the extensive (more of the same) and intensive (more trade but of different products) elements of trade growth. Lastly, market share is calculated as a measure of cost competitiveness to differentiate between the quality and cost elements of unit value. It is assumed that cost changes reflect process efficiency and not input costs and change in producer incomes. The framework developed, to measure product and process innovation using international trade statistics, is presented in Table 2.1. The framework illustrates four possible types of innovation performance:

- Failed product upgrading
- Product upgrading
- Product and process downgrading
- Process competitiveness

Table 2.1 Framework for assessing product and process upgrading and downgrading (Kaplinsky and Readman, 2005)

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING	*Quadrant 2* PRODUCT UPGRADING
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING	*Quadrant 4* PROCESS COMPETITIVENESS

Product upgrading refers to the introduction of new or significantly improved products faster than competitors (Kaplinsky, Morris and Readman 2002). This refers to an increase in the unit value of the product relative to the industry average and an increase in market share. To experience product upgrading, exporters must be innovating at a rate faster than global competitors. Process competitiveness refers to increasing the efficiency of internal processes so they are better than those of competitors (Kaplinsky, Morris and Readman 2002). Failed product upgrading in *Quadrant 1* indicates that producers are unable to offset rising prices by attractive products and as a consequence lose market share. Product and process upgrading in *Quadrant 2* reflects a rise in market share despite rising unit values. Product and process downgrading in *Quadrant 3* reflects failed product upgrading as despite falling unit values producers are unable to sustain market share. The underlying cause of process competitiveness in *Quadrant 4*, where unit values is falling and market share is increasing is unclear according to Kaplinsky and Readman (2005). However, as outlined above, Kaplinsky and Readman (2005) assume that process efficiency rather that reduced input costs or declining producer incomes is the driver.

It is important to note that there are alternative frameworks and data that could have been used to look at product and process innovation in the Irish dairy industry. For example, the use of the Community Innovation Survey, a survey of innovation activities of enterprise in Ireland and other EU Member States (Central Statistics Office, 2012), would have allowed the author to find the innovativeness of Irish dairy enterprises relative to other manufacturing sectors or other dairy enterprises in Europe. However, using the Kaplinsky and Readman (2005) framework and international trade data allowed me to find the innovation performance of specific categories of Irish products in the global market, where approximately 85% of Irish dairy produce is sold. The use of this framework allowed the author identify if Irish manufacturers are innovating at a faster, slower or the same rate as industry competitors and the implications of these findings for innovation policy.

2.1.2 The Research Question

The aim of this study is to measure the innovation performance of Irish dairy products, using trade data. The research question asked is *what is the relative innovation performance of Irish dairy products on the global market?* To answer this, the upgrading framework developed in Kaplinsky and Readman (2005) to assess product innovation is employed. The framework uses trade data on unit value and market share.

This is the first application of the framework to an agricultural domain. Previous work has used the framework to analyse other sectors such as furniture, horticulture, apparel, tourism and mobile phone industries (Bernhardt and Milberg 2011; Kaplinsky, Readman and Memedovic 2009; Kaplinsky and Readman 2005). The nature of agricultural products and in particular dairy products makes the analysis different. The main reason for this is the EU market support mechanisms that support the production of agricultural produce distort the unit values of product on this market. There is also a second industrial organisation issue not just specific to the agricultural sector which may impact the analysis. The intra-firm trade between the Irish and foreign multi-national companies located in Ireland and their affiliate firms in other locations present an opportunity for profit switching transfer pricing (pstp) which can distort the trade data, used to calculate the unit value and market share metrics. The potential influence of market supports and the practice of profit switching transfer pricing on the trade data used in this analysis are explored in section 2.4.2.

In the next section, an overview of the Irish dairy industry's exports is presented to establish the significance of dairy exports as a unit of analysis. In addition, the distribution of the total value of the dairy exports is examined to identify Ireland's most significant dairy exports.

2.2 The Irish Dairy Industry's Exports

In 2010, 85% of dairy products produced in Ireland were exported (Department of Agriculture Fisheries and Food 2010c). The total value of the exports in this year was €1.4 billion (Central Statistics Office 2012b) which accounted for approximately 30% of total Irish agri-food exports. Furthermore, the prospects for dairy product exports in the medium to long term are positive. This is based on a number of factors:

- Rising global demand for dairy products
- Expected increase in milk supplies, projected at 50% by 2020, arising from the Abolition of EU milk quotas in 2015
- Ireland's comparative advantage as a low cost producer of milk (due to a grass based production system).

Demand for dairy products in developed markets, such as Europe and Oceania, is relatively stable. Cheese and fresh dairy products are perceived as the potential drivers of growth (Donnellan et al. 2011). Rising global demand is mostly attributed to rising incomes, population growth and the westernisation of eating habits in developing and emerging nations. Growth rates in consumption are highest in Asia (Donnellan et al. 2011). Milk powders, notably in the area of infant milk formula, are in particular demand with the global market valued at US$10 billion in 2009 (Department of Agriculture Fisheries and Food 2010b). In particular, dairy consumption in the Chinese market is expected to grow by 43% by 2019 as consumers (of a population of 1.3 billion) increasingly view dairy products as an important nutritional food for children (Leslie 2012). Furthermore, demand for infant milk formula imports continues to grow strongly since the discovery in 2008 of the industrial chemical melamine in infant milk formula produced in China (Hussey 2013; Rabobank 2013).

The core activity in the Irish dairy industry is processing milk into consumer and intermediate products. These include butter, cheese, powdered milk products[15], casein, whey, infant milk formula and fresh milk produce. The product mix includes both differentiated and non-differentiated products referred to as value added and commodity products. Value added products include infant milk formula, specialised milk powders and butter and cheese products such as Kerrygold butter and Dubliner Cheese. The four largest Irish dairy exporters are Irish Dairy Board, Glanbia, Dairygold Co-operative and Kerry Group (Dobson, 2007). All four companies operate several subsidiary companies worldwide. The manufacture and exporting of infant milk formula in Ireland is dominated

[15] Powdered milk products refer to whole milk powder and skimmed milk powder and not infant milk formula. Powdered milk products are produced by eliminating the water from the product. Skimmed milk powder is an ingredient in infant milk formula.

by three foreign multi-national companies (MNC) namely Danone, Nestlé, and Abbott. These foreign MNCs export finished and unfinished infant milk formula products (Ketch 2012). Branded finished products produced in Ireland include Cow&Gate, Aptimal, Similac and Gain. In relation to the unfinished products, the MNCs produce the base product in Ireland using raw milk supplies and ship the product to global locations such as Europe and Asia for blending and packaging.

2.2.1 Dairy Product Selection

Innovation can increase the competitiveness of Irish dairy products on global markets. This study is concerned with identifying product and to a lesser extent process innovation in Irish dairy product exports. The innovation performance of three products is examined in this study: infant foods, cheese, and butter. In this section, the rationale for selecting these products is outlined.

Export data reported at five-digit Standard International Trade Classification (SITC) from the Irish Central Statistics Office (CSO) (2011) was used. Here, the values are presented in nominal terms. Infant milk formula is not classified as a dairy product in international trade. It is classified as a food product. By consultation with a statistician from the external trade department in the CSO, the author was informed that the product category '*food preparations for infant use*' is used to analyse trade in infant milk formula. The statistician estimates that approximately 90% of Ireland's exports categorised under this product relate to infant milk formula. Therefore, this study uses the trade food category '*food preparations for infant use*' as a proxy for infant milk formula and it is referred to as infant foods hereafter.

2.2.2 Distribution of Total Dairy Exports across Product Categories

Over the period, 2000-2010, Ireland exported seven category types of dairy produce. They included infant foods, cheese, butter, milk and cream concentrated or sweetened, whey, milk and cream and yoghurt. Figure 2.1 shows that no product category accounted for more than 35% of the total value of Irish dairy exports in any of the years between 2000 and 2010. This implies that the Irish dairy export base is diversified.

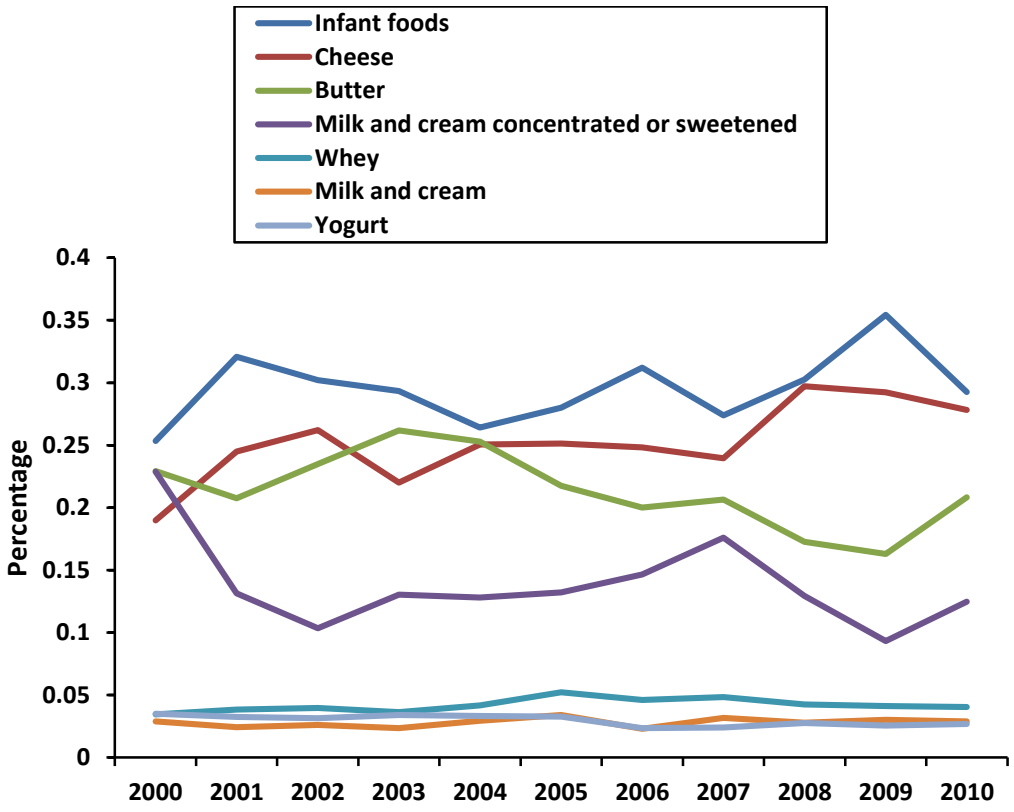

Figure 2.1 Share of total Irish dairy exports in terms of value over the period 2000 to 2010.
(Source: Based on CSO data)

In 2010, the value of all Irish dairy produce exports was €2.02 billion. In that year, infant foods, cheese, and butter accounted for the highest share of total exports - 29%, 28% and 21% respectively (Figure 2.1 and Figure 2.2). Furthermore, the combined value of the three product categories in 2010 accounts for 78% of total dairy product exports. This establishes infant foods, cheese, and butter as Ireland's most important dairy product exports. The butter and cheese manufacturing sector consist of nine butter and eight cheese plants, all Irish owned firms structured as either cooperatives or private limited. The infant foods sector, dominated by three foreign multi-national firms, consists of four manufacturing plants.

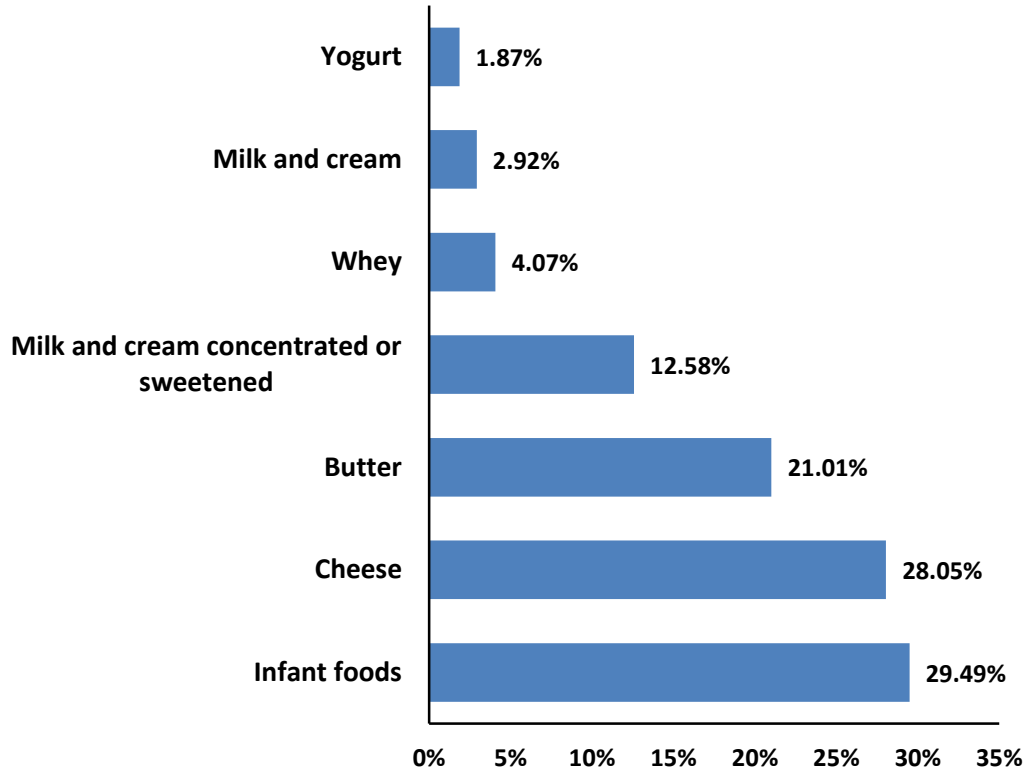

Figure 2.2 Product share of total value of exports 2010.
(Source: Calculations based on CSO data)

In section 2.5, a descriptive analysis of the trade performance of each of the three product types is presented. The analysis was undertaken to provide new evidence on the performance of Irish dairy exports in terms of their key markets and their main competitors. To date, industry reports and studies in the area of dairy exports have used highly aggregated data to examine dairy exports (e.g Bord Bia 2013a; Central Statistics Office 2012b; Prospectus and Promar 2003). In addition, as mentioned above, infant food produce are not included in the trade classification categories for dairy products. This has led to little evidence on the performance of Irish infant foods on global markets, although it is Ireland's most significant dairy export in terms of value (Figure 2.2). In the next section, the methodology of this study is outlined detailing the trade data used and the approach to data analysis.

2.3 Methodology

The purpose of the study is to measure the innovation performance of the Irish dairy value chain. The research question asked is *what is the relative innovation performance of Irish dairy products on the global market?* This question is addressed by applying the upgrading framework developed in Kaplinsky and Readman (2005) to measure the performance of Ireland's most significant dairy products – infant foods, cheese, and butter, over the period 2000-2010.

Data on imports and exports was collected for the following reasons. First,, export data was used to profile the three products in terms of markets and competitors. Second, import data was used to compute the unit value and market share measures for the upgrading analysis. In addition, industry experts were consulted to help interpret the analysis findings. The trade data sources are detailed in the following section.

2.3.1 Trade Data

The export data was sourced from the following three institutions:

- The Central Statistics Office (CSO) trade database
- The Eurostat 'COMEXT' database
- United Nations 'COMTRADE' database.

The CSO Ireland supplies data on Irish exports to the COMEXT and COMTRADE databases. Therefore, the value and volume of the export data used are consistent. The nomenclature and level of aggregation of the data sourced from the different databases differ. The type of data used is as follows. Export data at eight-digit Combined Nomenclature (CN) from the COMEXT database and export data at five-digit Standard International Trade Classification (SITC) from the CSO (2011) were used to identify the significant markets for Irish dairy exports. Export data at six-digit Harmonised System (HS) from the COMTRADE database was used to identify Ireland's main competitors in the global product markets. In COMTRADE, three-digit SITC is the highest level of disaggregation available. This is too low to provide an accurate assessment of infant food produce. Therefore, the HS classification system was used instead, as it provides six-digit level classifications of infant food produce and four-digit level classification for butter and cheese product groups. Personnel from the external trade department in the CSO informed the author that SITC 09893, which is food preparations for infant use, directly corresponds to the HS classification code 1901100, food preparations for infant use.

Import trade data on dairy products from Ireland was used. The World Trade Organisation (2012, p37) argues that import data is more accurate than export data as it is less likely to be used for taxation and trade restrictions purposes. The use of import data from partner countries for export analysis is referred to as 'mirroring' (World Trade Organization 2012; Eurostat 2006). Data on imports was sourced from Eurostat's 'COMEXT' database and the United Nations 'COMTRADE' database. Kaplinsky and Readman (2005) also used import data in their upgrading analysis.

COMEXT

The Eurostat COMEXT database reports intra-EU trade between Member States and EU trade with non EU members referred to as extra-EU trade. The intra-EU trade statistics measure value and quantity of goods traded between Member States. The trade statistics are collected via the Intrastat system where data is collected directly from trade operators (Eurostat 2006). Extra-EU trade statistics report the value and quantity of non-EU trade. Data sources are customs declarations and Single Administration Documents (SAD)[16] which accompany goods as they cross the state borders (Eurostat 2006). The value and volume measures of traded goods are consistent across the COMEXT database.

COMTRADE

The database provides detailed trade data on imports and exports by commodity and trading partners of 174 countries (United Nations Statistics Division/ Department of Economic and Social Affairs 2013). In 2012, the database contained data for 100 countries (or areas) representing approximately 83% of World trade (United Nations Statistics Division/ Department of Economic and Social Affairs 2013). Personnel from the CSO informed the author that there can be consistency issues with the volume measures listed on the COMTRADE database. However, after consultation with CSO staff, it was agreed that COMTRADE was the most appropriate data source on world trade. Thus, the data was assumed correct.

In the COMEXT and COMTRADE databases, imports are recorded on the cost-insurance freight (c.i.f) valuation basis and exports on the free-on-board (f.o.b) basis. This difference in reporting contributes to differences in exporting countries reporting of export trade and partner countries accounting of import received from the exporting country. This issue of c.i.f and f.o.b calculations play a smaller role in intra-EU trade recorded on COMEXT. For the purpose of the analysis in this study, the import statistics reported by partner countries from Ireland in both databases are assumed to represent true

[16] A customs document formulated by the EU to control the import and export of goods arriving and departing from EU nations

trade flows. As according to Kaplinsky and Readman (2005), use of import data reported on c.i.f basis (which includes expenses such as shipping and insurance and excludes duties) is a good indication of producer prices.

There are two approaches to reporting international trade in goods: general trade system and special trade system (Eurostat 2006). The general trade system includes all goods entering and exiting the economic territory of a country excluding simple transit trade. Goods placed in bonded warehouses and exports after bonded warehouses are included in the general trade system. The special trade system is a narrower concept and includes goods from foreign countries that go into free circulation in the receiving country. The difference between the general trade method of accounting and the special trade method has no influence on the upgrading analysis in this paper, as the statistics sourced from COMEXT and COMTRADE are not compared. In the COMEXT database, the extra-EU trade statistics are compiled using the special trade system. The intra-EU statistics are not compiled on a general or special trade basis as they have no direct link to customs procedures. The United Nations assemble data for COMTRADE based on the general trade system.

2.3.2 Challenges to Using the Kaplinsky and Readman (2005) Framework

There are two broad categories of limitations to using the Kaplinsky and Readman (2005) framework that need to be considered. The first category, relates to the assumptions underpinning the framework itself, i.e. those of product homogeneity and the equating of market share gains only with process efficiency. The second category relates to the empirical context – Irish dairy exports – how market supports and organisational practices such as profit switching transfer pricing (pstp) may bias the measures derived from trade data analysis. The following paragraphs address each of these limitations.

Product Homogeneity and Market Share

There are two limiting assumptions underpinning the upgrading framework developed in Kaplinsky and Readman (2005). The first is that products are homogeneous and the second is that increasing market share reflects process efficiency. To overcome the assumption of product homogeneity, this study uses the highest level of available disaggregated international trade statistics as practised in Kaplinsky and Readman (2005). In COMEXT, the highest level available is eight-digit which is reported using the Combined Nomenclature (CN). In COMTRADE, the highest level available is six-digit reported using the Harmonised System Commodity Description and Coding System (HS). CN incorporates the HS which provides disaggregated analysis of imports and exports in

consistent volume and value terms (Kaplinsky and Readman 2005). As such, this study assumes that volume and value terms are consistent across COMEXT and COMTRADE.

The second assumption is that market share changes reflect process efficiency and not reducing input costs or declining producer incomes. As suitable data on input costs or producer incomes was not readily available, following Kaplinsky and Readman (2005) the assumption of process efficiency is used in this analysis.

EU Market Supports

As the time period of the analysis occurs between 2000 and 2010, CAP market support mechanisms such as export refunds and intervention buying (butter and skimmed milk powder) for the years 2000-2009[17] and import duties for the entire period 2000-2010 need to be considered when examining the unit values and market share of butter and cheese products.

Export refunds were introduced to enable exports from the EU compete in global markets. They are subsidies paid for EU milk products exported outside the EU designed to cover the difference between EU market prices and lower world market price. This measure was reduced to a safety net in the CAP reform referred to as 'Health Check' in 2008. However, it was temporarily reintroduced in 2009 until year end to support low global milk prices. Import duties are charged to agricultural goods imported into the EU where world market prices are less than products on the EU market. This measure operates throughout the period of analysis in this study. The intervention buying scheme was designed to support basic products by removing surpluses of butter and skimmed milk powder (SMP) from the market. This market support operated until 2008 when it was also reduced to a strict safety net as part of the CAP reform.

In this study, data on Irish cheese and butter produce in the EU importing market is used to calculate unit value and market share measures. In the EU market, export refunds are not available for Irish exporters and so have no influence on the unit value and market shares calculations. It is worth noting, that the trade restrictions and import duties applied to dairy produce received from non-EU countries[18] may be artificially increasing the unit values received for all produce sold in the EU import market. In the ensuing analysis, the EU unit import price of produce from Ireland is calculated relative to the average unit

[17] Market supports were temporarily reintroduced in 2009 until year end to help stabilise falling commodity product prices.

[18] Some non-EU countries have negotiated quotas allowing them to sell produce in the EU without tariffs.

value of EU import. Therefore, inflated prices and market supports will have no effect on the unit value calculations.

Profit Switching Transfer Pricing

Multi-national companies (MNCs) play a dominant role in the manufacture of Irish dairy product exports. The availability of processed milk is one of the reasons these MNCs manufacture in Ireland (Clancy et al. 2001). Other reasons for locating in Ireland include the low cost of raw milk (as production is mostly a grass based system) (Dobson 2007), good milk quality, and the low corporation tax regime for profits from trading activities.

International trade between MNCs and their foreign affiliates is referred to as intra-firm trade. The prices of goods sold between affiliated enterprises are known as transfer prices (Lanz and Miroudot 2011). As stated in the Finance Bill 2010 (p2), transfer pricing is a *'normal and necessary feature of transactions within large groups of companies'.* The guidelines for setting transfer prices is to use the 'arm's length principle' as set out in OECD (2011) publication Transfer Pricing Guidelines for Multinational Enterprises and Tax Administrations. An arm's length price is the price the transaction would be on the open market between non-affiliated parties. When transfer pricing includes an artificial element of profit and loss, Stewart (1989) refers to this practice as profit switching transfer pricing (pstp). Given Ireland's low corporation tax rate of 12.5%, MNCs located in Ireland may have an incentive to engage in pstp.

Several authors have noted that Irish export performance may reflect pstp (O'Brien and Scally 2012; Holohan and Walsh 2002; Stewart 1989). One implication is that it might artificially increase recorded output levels, what Stewart (1989, p) called a 'nominal output effect', and in the context of the following analysis, this would overinflate the true value of Irish exports. This has implications for the Kaplinsky and Readman (2005) framework. Detecting pstp in trade data ideally requires firm level information on intra-firm trade (Bonturi and Fukasaku 1993) which is difficult to source and outside the scope of this study. Nevertheless, it is important to get some idea whether or not pstp exists in the sector, and if it does, whether it has changed over the period in question. The strategy to do so has two components.

First, it is possible to make a judgement on the likelihood of the existence of pstp in the sector using published trade data and input from industry experts. This is done by identifying whether vertical intra-industry trade exists in the sector using the Green Hine and Milner (GHM) index. The presence of vertical intra industry trade suggests that the opportunity for pstp to occur exists as this type of trade includes inter-firm and intra-firm

trade. Information gained from interviews with industry experts can then be used to gauge their opinion on whether in their opinion pstp does exist and the relative importance of pstp in each dairy product category.

Second, it is actually more important for this analysis to identify whether or not if pstp exists, the extent it has changed over time. If it has not changed, then it does not necessarily impact on the interpretation of the implied innovation performance identified in the study. One indicator to use to proxy the extent of pstp is the ratio of GDP to GNP. As the difference between these two measures is to a large part determined by the activities of MNC's in Ireland, a relatively stable ratio can be interpreted here as a relatively constant rate of pstp over the period.

Is there evidence of pstp in the dairy sector?

The GHM ratio is a unit value index, used to differentiate between vertical trade and horizontal trade (Azhar and Elliott 2006). Vertical intra-industry trade refers to the simultaneous export and import of goods classified in the same sector but at different stages of production (OECD 2002), indicative of the distribution of the production process across different locations. This can be undertaken by a number of different firms or affiliated firms. The latter situation provides an opportunity for pstp. Horizontal intra-industry trade is the other type of intra-industry trade which involves the simultaneous export and import of products classified in the same sector and at the same stage of processing but are differentiated (OECD, 2002). Therefore, horizontal intra-industry trade flows involve goods that are similar in quality, whereas, vertical intra-industry trade flows involve goods that are significantly different in quality (Azhar and Elliott 2006).

The index is calculated as follows:

$$GHM_{lik} = (1-\alpha) \leq \left(\frac{UV_{Xlik}}{UV_{Mlik}}\right) \leq (1+\alpha)$$

where *UV* is unit value, where *X* is exports, *M* is imports, *l* is industry, *k* is product and α is 0.15.

Using the distribution percentile of 0.15, vertical trade is defined as outside of the percentile (less than 0.85 and greater than 1.15) and horizontal trade is defined within the distribution percentile (Azhar and Elliott 2006).

Using trade data at five-digit SITC, the GHM index is calculated and reported in Table 2.2 for each of the years 2000 to 2010. The values indicative of vertical trade are listed in black text. At five-digit SITC, cheese produce is distributed across five types: grated, processed, blue veined, fresh, and other.

Table 2.2 GHM index for butter, cheese and infant foods over the years 2000 to 2010

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Infant foods	**1.29**	**1.55**	**1.68**	**1.82**	**1.74**	**1.17**	0.89	0.99	**2.14**	**1.16**	**1.35**
Grated	**1.41**	1.09	1.02	**1.22**	**1.28**	1.00	0.91	1.11	1.12	0.94	0.92
Processed	**0.84**	**0.77**	**0.78**	0.93	1.01	0.89	1.12	1.07	**1.26**	**1.20**	1.13
Blue Veined	**1.26**	**0.71**	**0.68**	**1.29**	**0.80**	**0.44**	**0.51**	**0.77**	1.12	0.97	**1.35**
Fresh	**0.76**	**0.70**	**0.61**	**0.68**	**0.81**	**0.78**	**0.79**	0.97	**1.20**	**1.18**	**1.52**
Other	**0.82**	0.85	0.86	0.93	0.89	**1.29**	**0.84**	0.92	0.92	0.85	0.93
Butter	1.01	1.11	1.00	0.99	0.96	0.98	0.90	**1.20**	1.11	1.08	**1.28**

The results show that over the eleven year period, Ireland's intra-industry trade in infant foods, blue veined cheese and fresh cheese produce was mainly vertically differentiated. This implies that Irish imports and exports differ in quality indicating the distribution of the production process across different locations which provides an opportunity for pstp. On the contrary, Ireland's intra-industry trade in butter and grated cheese was mainly of a horizontal nature whereby imports and exports are similar in quality.

As previously mentioned, the trade data does not differentiate between intra-firm trade and intra-industry trade. So to explore this issue, the author consulted with a number of industry analysts to first develop an understanding on the extent of intra-firm trade accounted for in the trade statistics and second to determine if pstp is present, is it likely to be constant over the period of analysis. The consultations were multiple and ad hoc, conducted through telephone conversations and email. The personnel that participated are as follows:

- Statisticians from the external trade department in the CSO (CSO statisticians hereafter)
- A trade analyst from the Irish Dairy Board (IDB trade analyst hereafter)
- An industry analyst from Enterprise Ireland (EI analyst hereafter).

Consultations with the IDB and EI analysts reveal pstp opportunities for Irish MNCs. Over the past decade, Irish MNCs involved in the production of butter and cheese produce progressively shifted segments of production such as processing and packaging to other European locations. For example, the IDB analyst estimates that 40% of IDB exports are intra-firm trade. The analyst explained that similar to other Irish dairy MNCs, the Irish Dairy Board is increasingly processing and packaging products in other locations such as Great Britain and Germany. This is to generate higher scales of efficiencies which the analyst reasons as unobtainable in Ireland. Concerning the infant foods sector, the consultations with the personnel show that it is likely that the level of intra-firm trade in this sector is higher than that for butter and cheese. Once again, this provides pstp opportunities for the manufacturers. Although opportunities exist for pstp, the CSO statisticians stated that they are not suspicious of pstp in the dairy manufacturing sector but are aware of the practice in the pharmaceutical sector.

Is there evidence of the extent of pstp changing over time?

Assuming a level of pstp is occurring, the relative unit value and market share calculations in this study for unfinished products (i.e. requiring further processing or packaging) may be overinflated. The calculations of unit value and market share are not static but reflect performance over the time period, 2000 to 2010. Based on the relatively stable GDP to GNP ratio shown in Figure 2.3, there is no evidence to suggest fluctuations may occur in the percentage of price of product which accounts for profit switching activity, therefore the rate of pstp over the period is assumed constant.

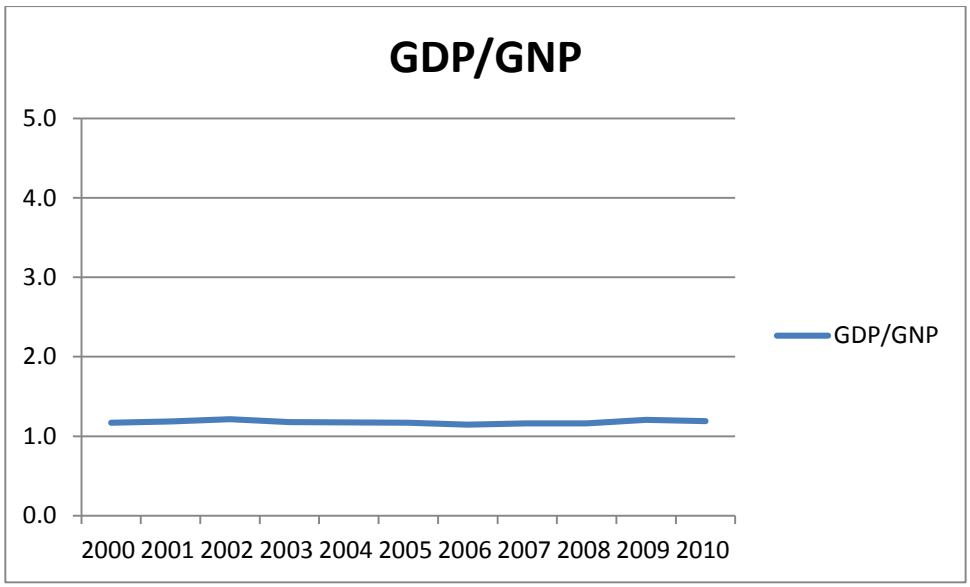

Figure 2.3 GDP/GNP ratio for each of the years 2000 to 2010 inclusive
(Source: Calculations based on COMTRADE data)

To sum up, it is concluded that intra-firm trade is accounted for in Irish export statistics. Based on Ireland's stable low corporate tax rate over the period 2000-2010, transfer pricing presents the opportunity for pstp. The findings from the GHM index and the consultations with industry specialists help conclude that it is likely that pstp is occurring. For the purposes of this analysis, it is important to know if the extent of pstp is constant over the analysis period. The findings from the GDP/GNP ratio show that it is constant, therefore, pstp has no impact on the innovation performance analysis.

2.4 Results: Profiling Irish Dairy Exports

In this section, the preliminary findings from an analysis of the export data on the three dairy exports, infant foods, cheese, and, butter, are presented. The section begins with a review of the performance of each of the products in terms of volume over the period 2000-2010. Next, in section 2.5.1, the significant markets for Irish dairy exports are presented. Finally, in section 2.5.2, Ireland's main competitors in each of the global product markets are outlined.

Over the period 2000-2010, the percentage change in the exports of all three product categories was positive. Figure 2.4 shows the percentage change in output of the three dairy product exports over the period 2000-2010. Cheese experienced a 97% change. In contrast, infant foods and butter experienced changes of approximately 28% and 10% respectively.

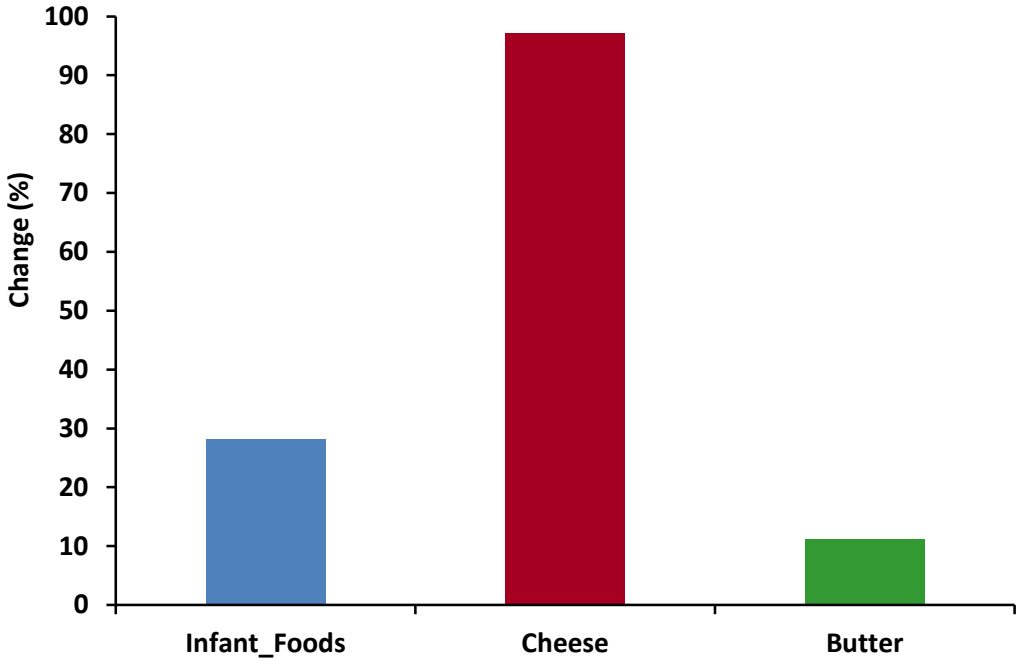

Figure 2.4 Percentage change in total output (kg) of Irish infant foods, cheese and butter exports for the period 2000-2010.

Figure 2.5 shows the percentage changes in the global market for Irish infant foods, cheese, and butter exports over the period 2000-2010. It is evident that Irish infant foods and butter lost market share. On the contrary, cheese experienced a percentage change in the share of global market value of 8% over the period 2000-2010 (see Table A.1, Appendix A for further detail). The percentage change in the share of global market value for infant foods and butter is negative, -44% and -30% respectively.

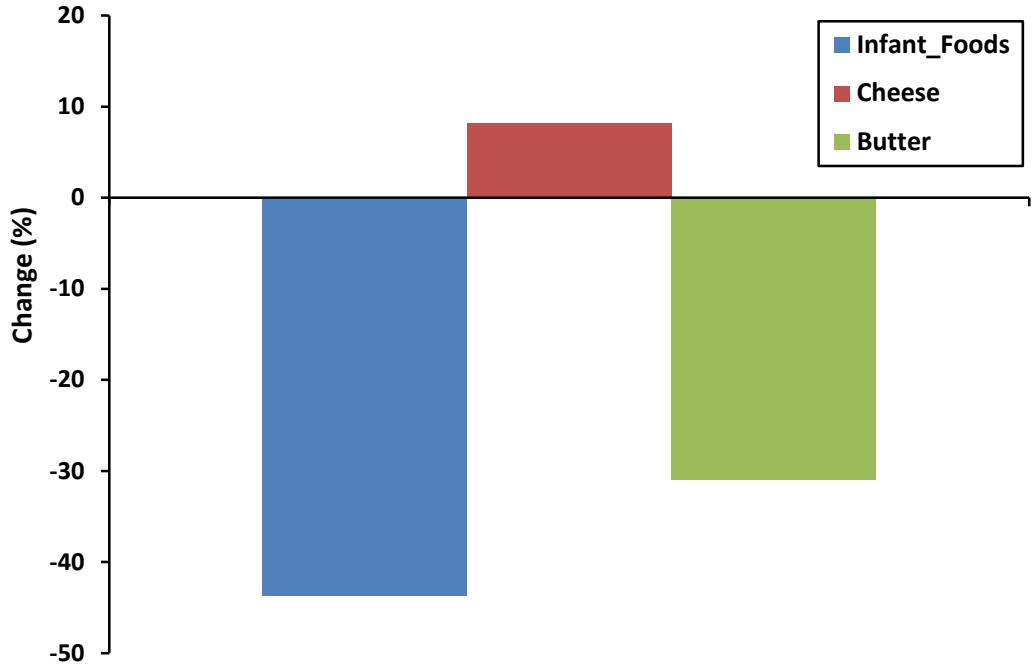

Figure 2.5 Percentage change in global market share for Irish infant foods, cheese, and butter for the period 2000-2010.

2.4.1 Global Markets: Destination of Irish Dairy Exports

The significant markets in terms of value differ across the product categories. Figure 2.6 shows that over 70% of global export value of Irish infant food products are achieved in non-EU markets. In contrast, for cheese and butter exports, the EU market is a more important market than the non-EU market in 2010. For this reason, this study examines the relative innovation performance of cheese and butter products in the EU market. The results are presented in section 2.7 and section 2.8 respectively.

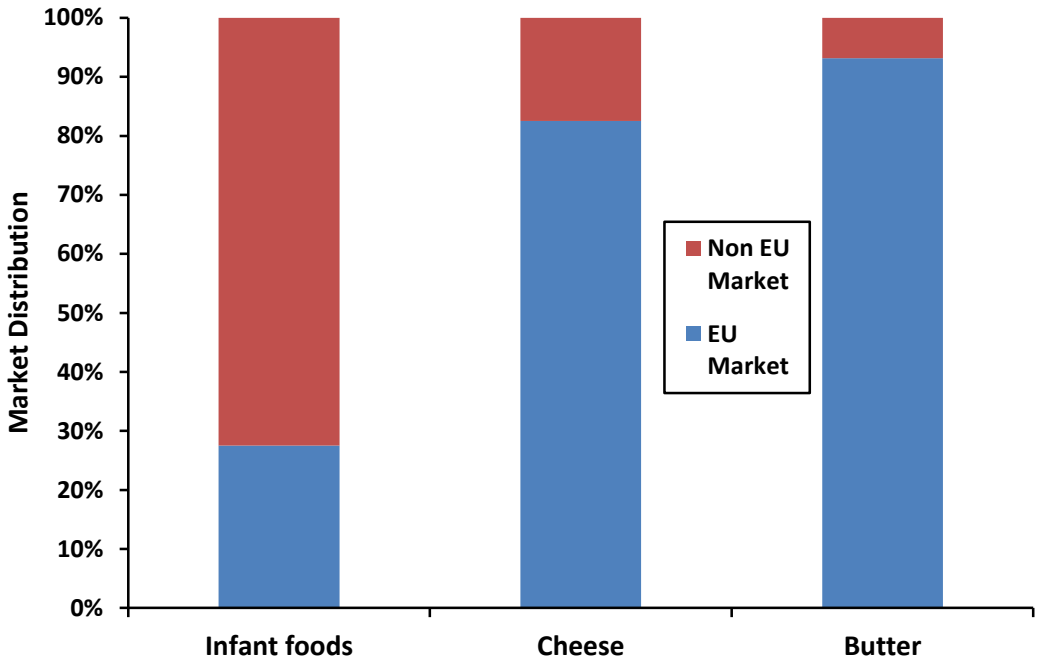

Figure 2.6 Distribution of infant foods, cheese, and butter on global markets 2010, in terms of value

(Source: Calculations based on COMTEXT data)

Infant foods

Ireland exported infant food product to 75 countries in 2010 (Central Statistics Office 2011a). More specifically, in that year, six countries accounted for 63% of the total exports, each accounting for 3% or more of total Irish infant food exports (Figure 2.7). These countries are shown in Figure 2.7.

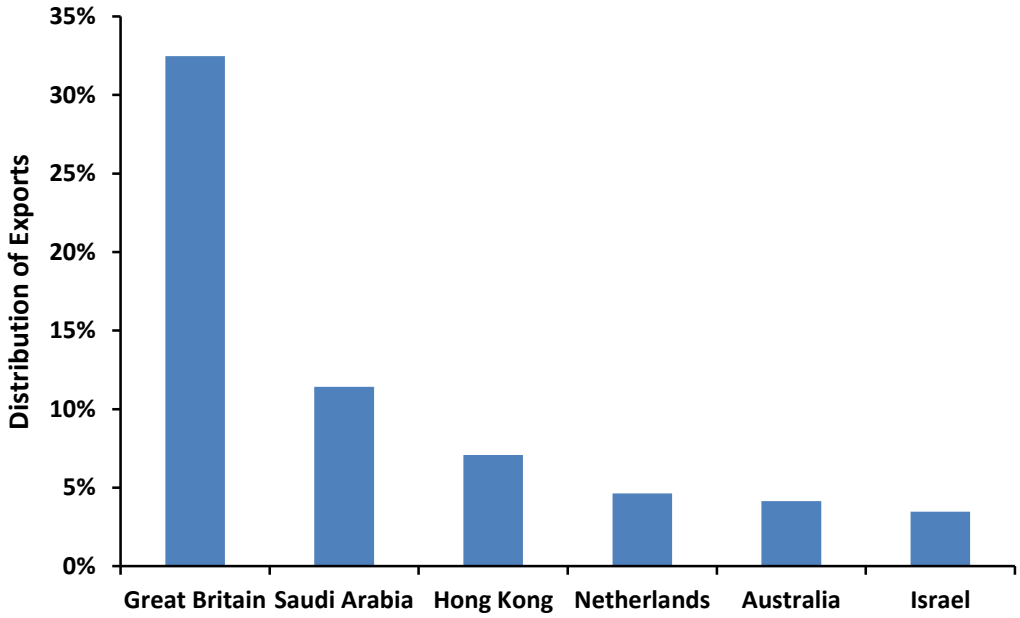

Figure 2.7 Distribution of Irish infant food exports in 2010, in terms of value. (Source: Author's calculations on CSO data)

Over the period 2000-2010, Great Britain was consistently the largest market for Irish infant food produce (Figure 2.8). Furthermore, the volume of exports traded in the market increased over the period. Contrary to the other markets, the volume of produce exported to Hong Kong and the Netherlands decreased over the period.

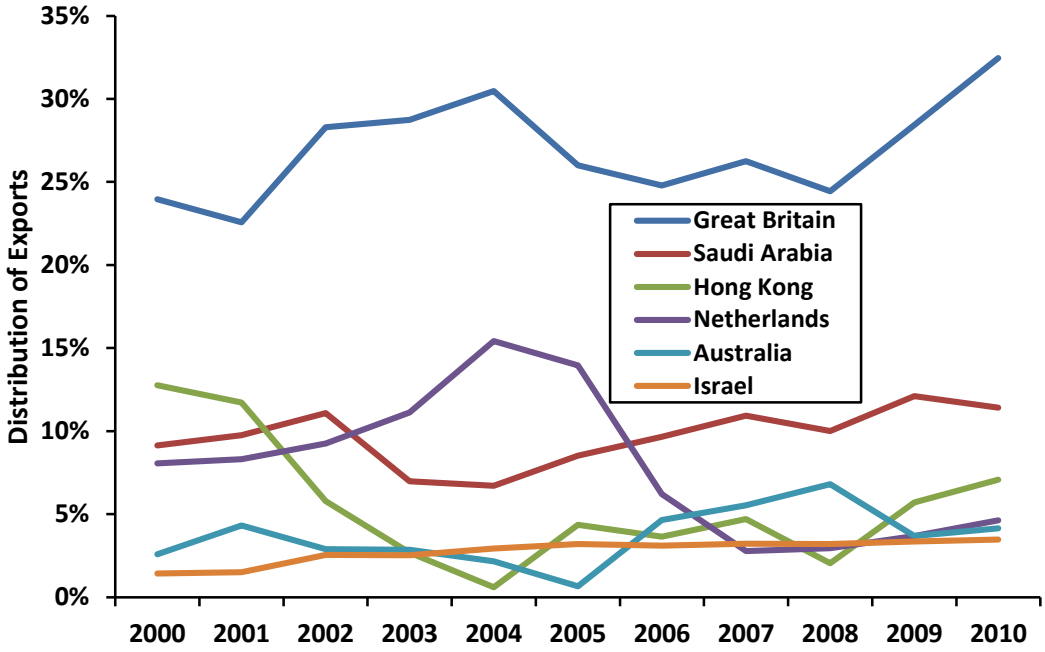

Figure 2.8 Distribution of Irish infant food exports, across significant markets over the period 2000-2010, in terms of volume.

(Source: Calculations based on CSO data)

Cheese

Ireland exported cheese to 62 countries in 2010 (Central Statistics Office 2011a). Thirteen countries accounted for 93% of the total cheese exports in the year. As shown in Figure 2.9, Great Britain was the largest market receiving 56% of total exports, which was five times greater than that received by the second largest market Germany (8%).

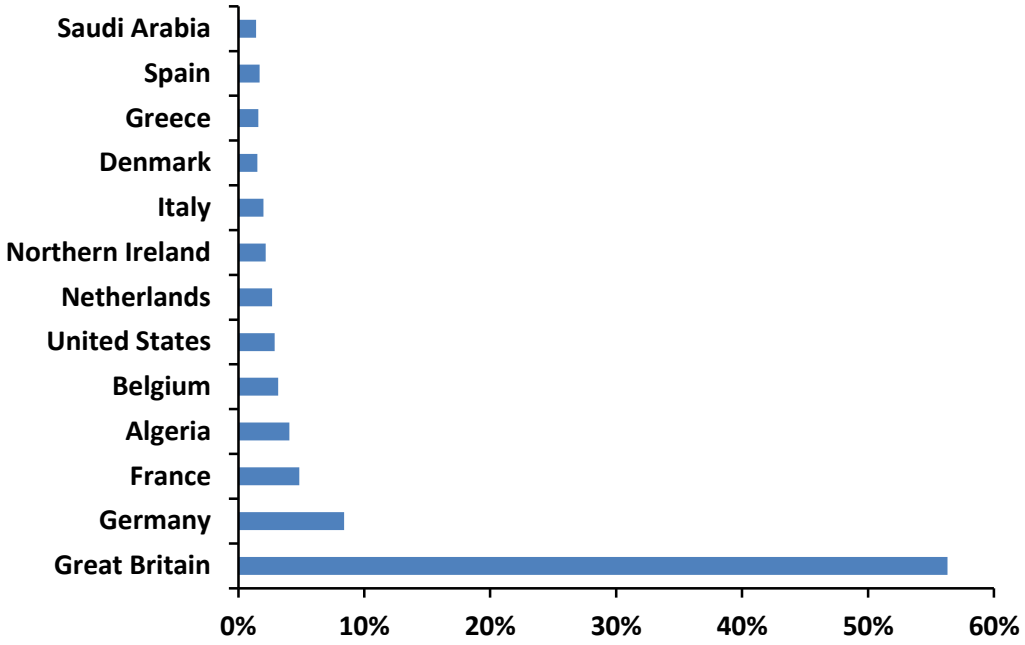

Figure 2.9 Distribution of Irish cheese exports in 2010, in terms of value.
(Source: Calculations based on CSO data)

Similar to infant food exports, Great Britain is consistently the largest market for Irish cheese exports over the period 2000 and 2010 (Figure 2.10). However, the volume of exports traded in this market has fallen from 2000 to 2010.

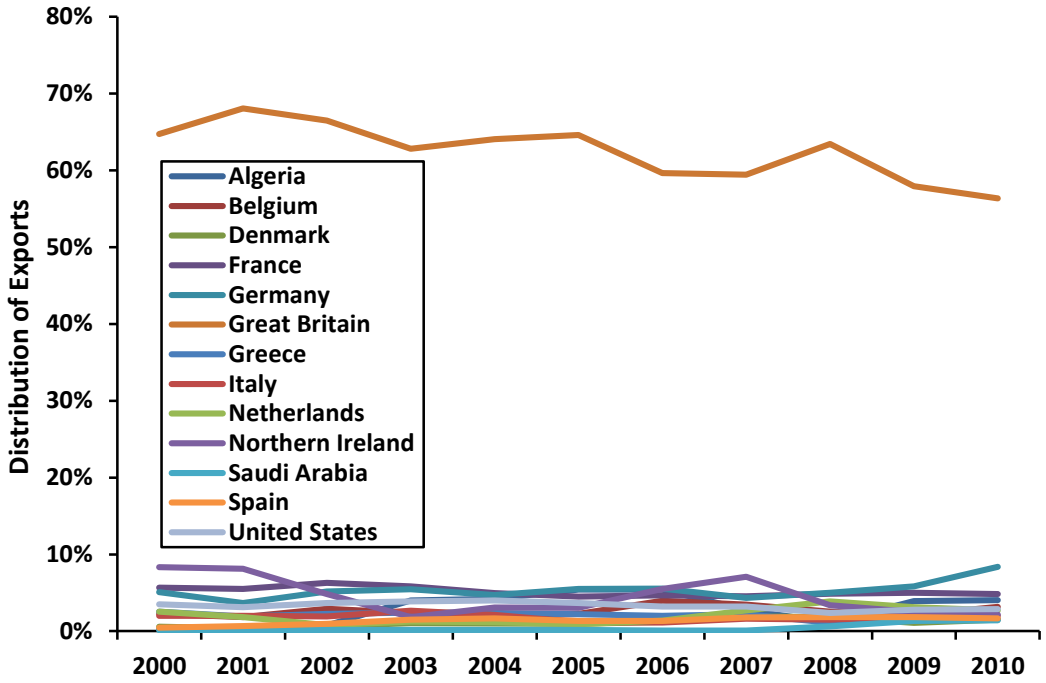

Figure 2.10 Distribution of Irish cheese exports, across significant markets over the period 2000-2010 in terms of volume.

(Source: Calculations based on CSO data)

Butter

Ireland exported butter produce to 61 countries in 2010 (CSO, 2011a). Six countries accounted for 91% of total butter exports. These countries (shown in Figure 2.11) included Germany (32%), Great Britain (22%), Belgium (15%), France (11%), Netherlands (7%) and Northern Ireland (4%).

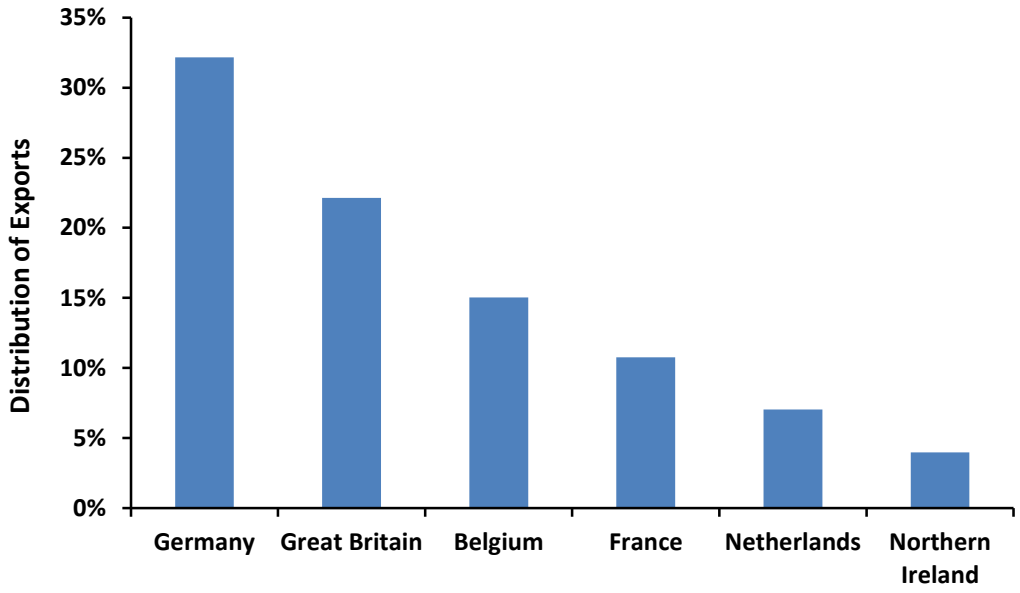

Figure 2.11 Distribution of Irish butter exports in 2010, in terms of value.
(Source: Calculations based on CSO data)

Over the period 2000-2010, Germany is consistently the largest market for Irish butter produce (Figure 2.12); however, the volume of exports has decreased slightly over the period. Great Britain remains the second largest market over the years, growing over the period. Exports to France and to a lesser extent the Netherlands decreased over the period.

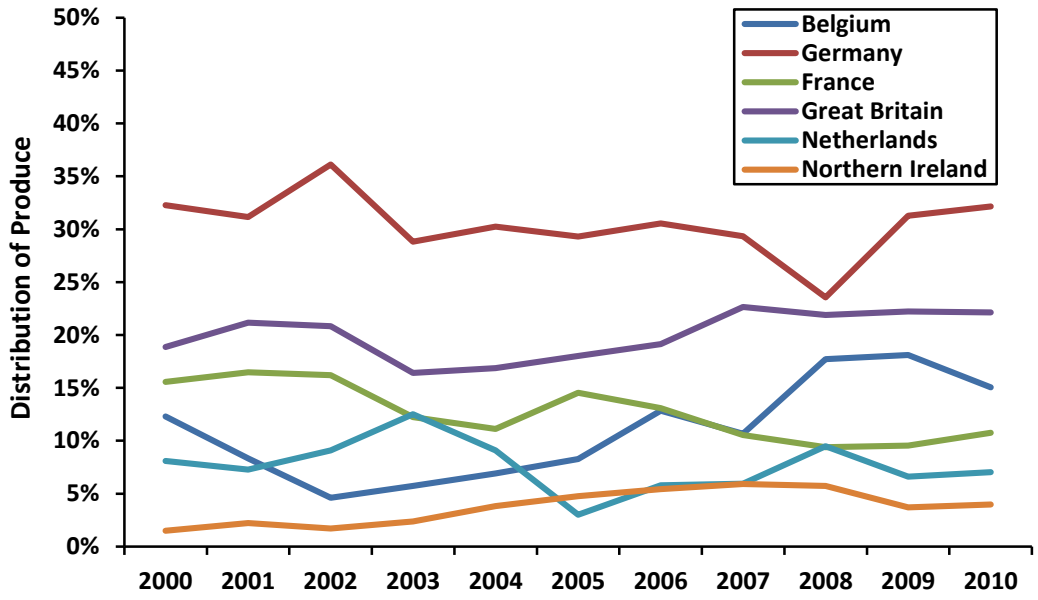

Figure 2.12 Distribution of Irish butter produce, across significant markets over the period 2000-2010, in terms of volume.
(Source: Calculations based on CSO data)

2.4.2 Competitors: Leading Producers of Product Categories

Infant foods

Ireland's main competitors in the market in 2010 are the Netherlands, France, Singapore and Germany. Table 2.3 outlines the gross value and volumes of each of the leading exporters in the global infant food market in 2010, of which Ireland is the second largest contributor. Ireland was the largest global exporter of infant foods, in terms of value. Over the period 2000-2010, Ireland experienced a -43.75% change in its share of global market. Singapore experienced a dramatic 7000% change in its share of global market over the period. In 2000, the total value of Singapore's exports of infant foods was US$160,000. This increased to US$433 million in 2010.

Table 2.3 The gross value (US$ million), volume (million kg) and percentage change of global market share of the leading global exporters of infant food produce in 2010.

Country	Gross value of exports 2010 (US$ million)	Gross volume of exports 2010 (million kg)	Percentage change in Global Market Share 2000-2010 (%)
Netherlands	1,017	144	15.77
Ireland	782	97	-43.75
France	471	99	17.07
Singapore	439	38	7,363.56
Germany	272	40	-33.65

Source: Author's calculations from COMTRADE data

Figure 2.13 indicates the percentage change in market share over the period 2000-2010.The Netherlands increased its overall market share by 15.77% while France increased its market share by 17.07%. In contrast, Ireland experienced a decrease in its market share of 43.75%. It is known that Ireland exports base powders for use in the production of infant milk products in Europe (O'Keeffe 2011). This unfinished Irish infant food product which is traded between affiliated firms in other European locations receives a lower unit value than the finished product accounted in the export trade statistics for the European countries. It is this intra-firm trade of unfinished products that presents opportunities for pstp. But, as previously mentioned the percentage of Irish exports of infant foods which account for unfinished produce is not known and the trade data on infant foods cannot differentiate between finished and unfinished product. The decrease in Ireland's market share may be attributed to an erosion in Ireland's price competitiveness or to Ireland's production levels not being able to keep up with demand. In terms of value, Ireland is losing global market share over the period as shown in Figure 2.13.

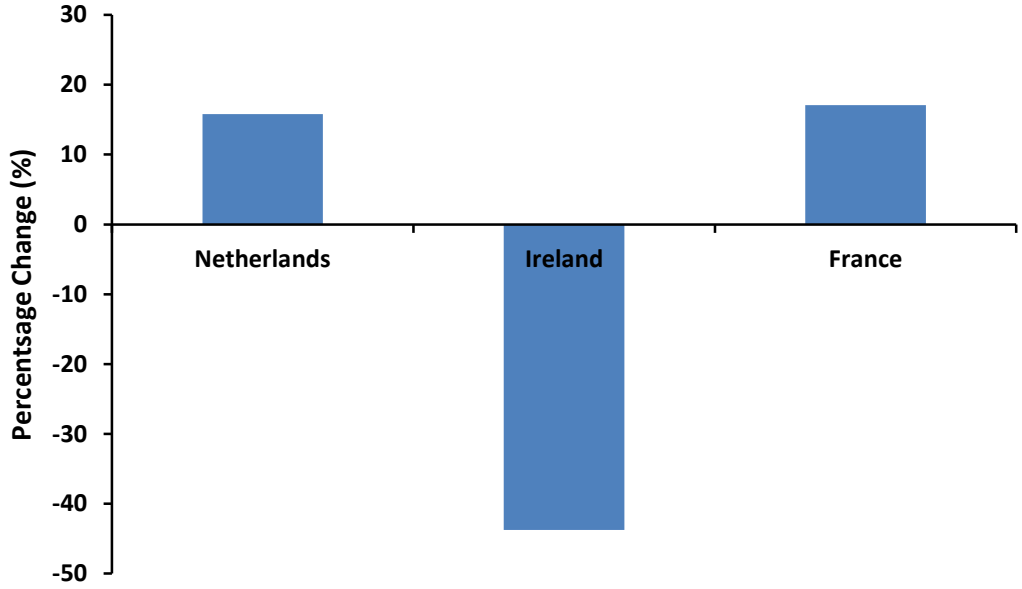

Figure 2.13 Percentage change in market share of global infant foods exports in the Netherlands, Ireland and France 2000-2010 by value.
(Source: Calculations based on COMTRADE data)

Cheese

COMTRADE reports the value of the global cheese market at US$25.5billion in 2010. Ireland ranks as the 8th largest exporter of cheese in 2010 (Table 2.4). Ireland's global competitors include Germany, France, Netherlands, Italy, Denmark, New Zealand, Belgium, Ireland, USA and Australia.

Table 2.4 The gross value (US$ million) and volume (million kg) of the leading global exporters of cheese produce in 2010.

Country	Gross value of exports 2010 (US$ million)	Gross volume of exports 2010 (million kg)
Germany	3,989	1,109
France	3,524	640
Netherlands	3,237	681
Italy	2,198	272
Denmark	1,351	262
New Zealand	1,023	265
Belgium	789	164
Ireland	743	178
USA	702	175
Australia	667	160

Source: Author's calculations on COMTRADE data

Over the period 2000-2010, Irish cheese exports experienced an increased share of the global market, as did those of the USA, Germany and Italy (Figure 2.14). Other competitors, namely France, Netherlands, Denmark, New Zealand, Belgium, and Australia experienced a decreased market share.

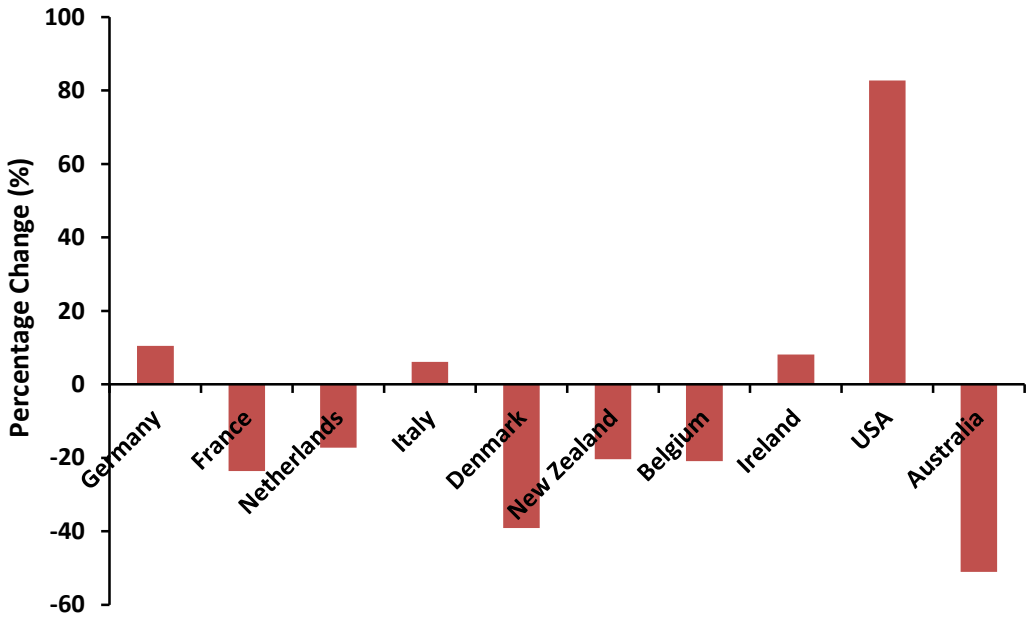

Figure 2.14 Percentage change in market share of global cheese exports of the leading exporting countries 2000-2010.

(Source: Calculations based on COMTRADE data)

Butter

COMTRADE report the value of the global butter market at US$ 6.4 billion in 2010. The top five global exporters of butter are New Zealand, Netherlands, Belgium, Ireland and Germany (Table 2.5). Ireland is the fourth largest exporter of butter in 2010, in terms of value.

Table 2.5 The gross value (US$ million) and volume (million kg) of the leading global exporters of butter produce in 2010.

Country	Gross value of exports (US$ million) 2010	Gross volume of exports (million kg) 2010
New Zealand	1,545.26	395
Netherlands	820.63	182
Belgium	653.05	133
Ireland	557.86	134
Germany	514.44	112

Source: Author's calculations on COMTRADE data

Figure 2.15 shows that over the period 2000-2010, Irish butter experienced the largest fall in global market share (-31%) relative to other leading exporters. In contrast, Germany's share of the global market increased by 51% over the period 2000-2010.

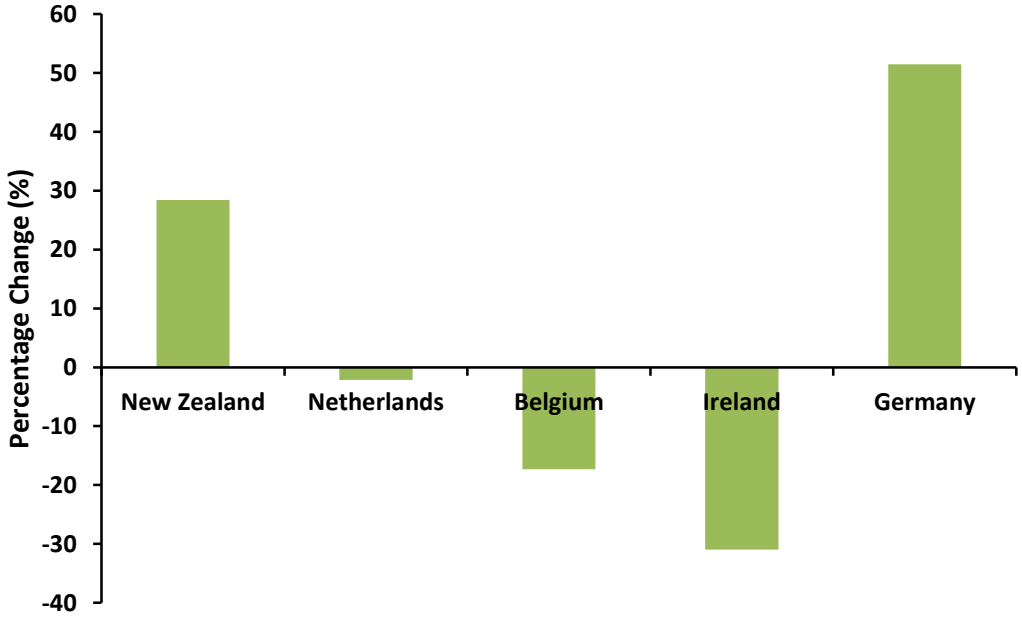

Figure 2.15 Percentage change in market share of global butter exports of the leading exporting countries 2000-2010 in terms of value

(Source: Calculations based on COMTRADE data)

The remainder of this study is concerned with the relative innovation performance of each of the product categories for the period 2000-2010. To address this, the upgrading framework illustrated in Table 2.1 is applied. Furthermore, to identify changes in innovation activity, the performance over the period 2000-2005 and 2006-2010 are measured and compared.

To measure the upgrading performance of cheese and butter, imports from Ireland on the EU import market over the time period 2000-2010 are examined. The EU import market includes EU and non-EU imports. Therefore, the data on extra-EU and intra-EU imports from Eurostat's COMEXT database are aggregated to reflect the EU import market. To measure the upgrading performance of infant foods, data on global imports from Ireland are sourced from the United Nations COMTRADE database.

The results on the upgrading performance are presented in Section 2.6 (Results: Upgrading Performance of Infant foods), Section 2.7 (Upgrading Performance of Cheese) and Section 2.8 (Upgrading Performance of Butter). Each of the three sections is organised as follows. First the upgrading performance of the product or the collective group of products over the period 2000-2010 is outlined. Second, the period 2000-2010 is divided into two sub periods: 2000-2005 and 2006-2010. The upgrading performance of each product within each period is outlined, with reference to total value of product imports from Ireland in the end year, 2005 and 2010 respectively.

2.5 Results: Upgrading Performance of Infant Foods

The section is structured as follows. First, the upgrading performance of infant foods in the global market is outlined for the period 2000-2010 and then compared across the two time periods 2000-2005 and 2006-2010. Second, the upgrading results on Irish infant foods in significant markets are outlined in section 2.6.2. These markets include Asia, Europe and Australia. The results show the upgrading performance over the period 2000-2010 and sub periods, 2000-2005 and 2006-2010.

2.5.1 Performance in the Global Market 2000-2010

The global import market for infant food produce more than doubled over the period 2000-2010 (See Figure A.1 for further details). The market is valued at US $4.4 billion in 2010 (based on COMTRADE data). Imports from Ireland were valued at US $666.9 million in 2010 and represented a 15.3% share of the global import market. Applying the upgrading framework, to assess Ireland's relative innovation performance on the market, Irish exports fall within Quadrant 3 (Table 2.6). This trajectory reflects product and process downgrading.

Table 2.6 The upgrading performance of Irish infant food produces on the global market.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING	*Quadrant 2* PRODUCT UPGRADING
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING World	*Quadrant 4* PROCESS COMPETITIVENESS

This reflects an inability to sustain innovative capacity, despite lowering product prices. But, there is another potential reason for the fall in relative unit value. It is evident from Figure 2.16 that the volume of Irish infant foods sold on the global market increased over the period 2000-2010. The trade data cannot differentiate if the increase is due to an increase in the export of finished or unfinished product whereby unfinished products receive lower prices as they require further processing and/or packaging. It is known that the infant food manufacturers located in Ireland export both unfinished and finished produce however there is no empirical evidence on the percentage breakdown.

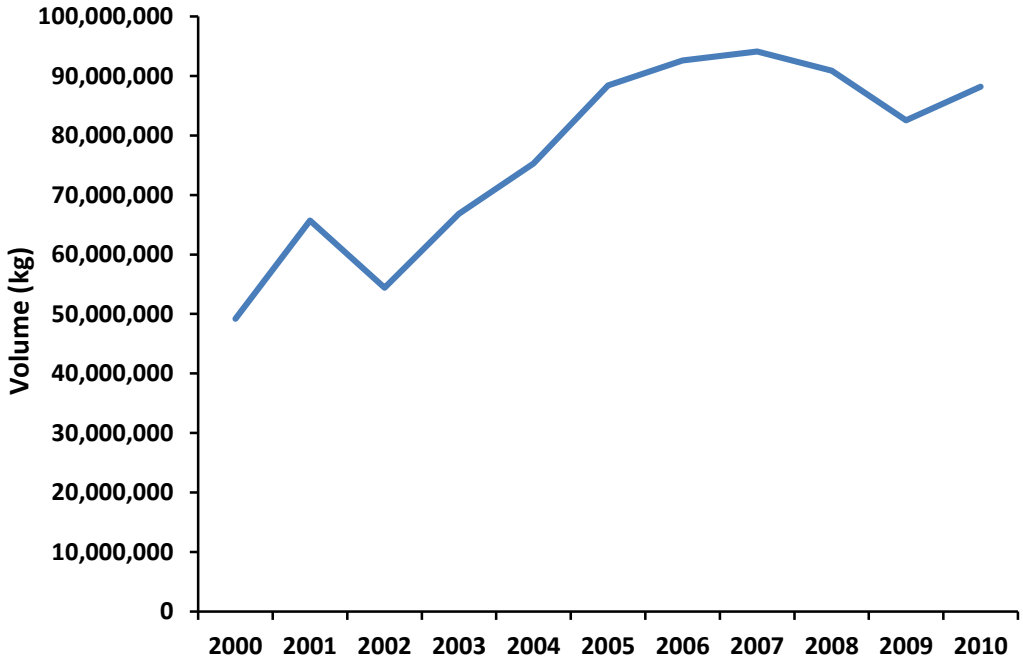

Figure 2.16 The volume of imports from Ireland sold on the global market 2000-2010. (Source: Calculations based on COMTRADE data)

Comparative Analysis of Time Periods

The time period 2000-2010 is split into two subgroups, 2000-2005 and 2006-2010, and the framework is once again applied to each. Over the period 2000-2005, infant foods from Ireland experienced product and process downgrading (Table 2.7). Over the period 2006-2010, there is no change in performance, as market share continued to fall as the relative price of Irish infant foods decreased. This reflects an inability to sustain innovation activity.

Table 2.7 The upgrading performance of infant food preparations products on global markets, 2000-2005 and 2006-2010 periods.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING	*Quadrant 2* PRODUCT UPGRADING
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING World (2000-2005) World (2006-2010)	*Quadrant 4* PROCESS COMPETITIVENESS

2.5.2 Performance in Significant Markets – Asia, Europe, and Australia

The global value of imports from Ireland in 2010 was US$ 667 million. The significant markets, in terms of total value, were Asia[19], Europe[20], and Australia receiving 39%, 38% and 16% respectively (Figure 2.17).

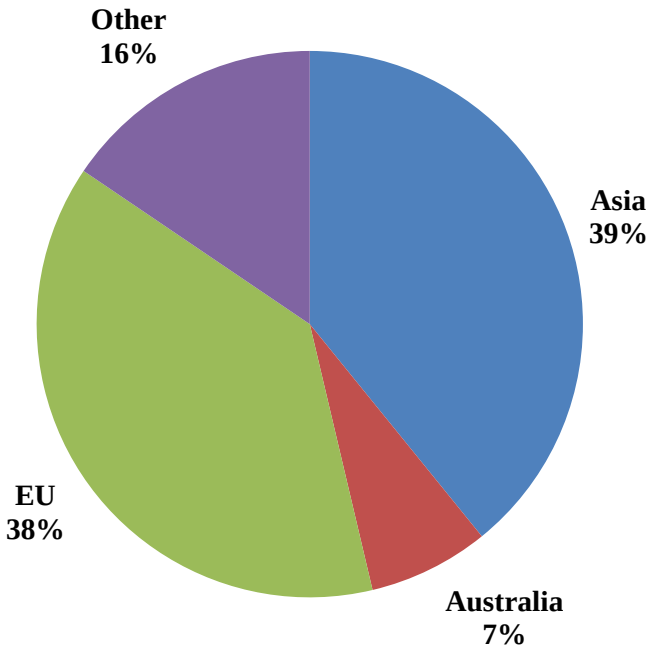

Figure 2.17 Destination of infant food preparations (2010).
(Source: Calculations based on COMTRADE data)

[19] See Table A.2 for list of countries used to denote Asia
[20] See Table A.3 for list of countries used to denote Europe

The three markets experienced growth over the period 2000-2010 as shown in Figure 2.18. Furthermore, the Asian infant food market tripled in size over the period, to become the largest market for infant foods. This reflects the growing demand for infant food imports influenced by the increasing westernisation of eating habits. The upgrading performance of infant foods from Ireland in each of these markets is illustrated in Table 2.8.

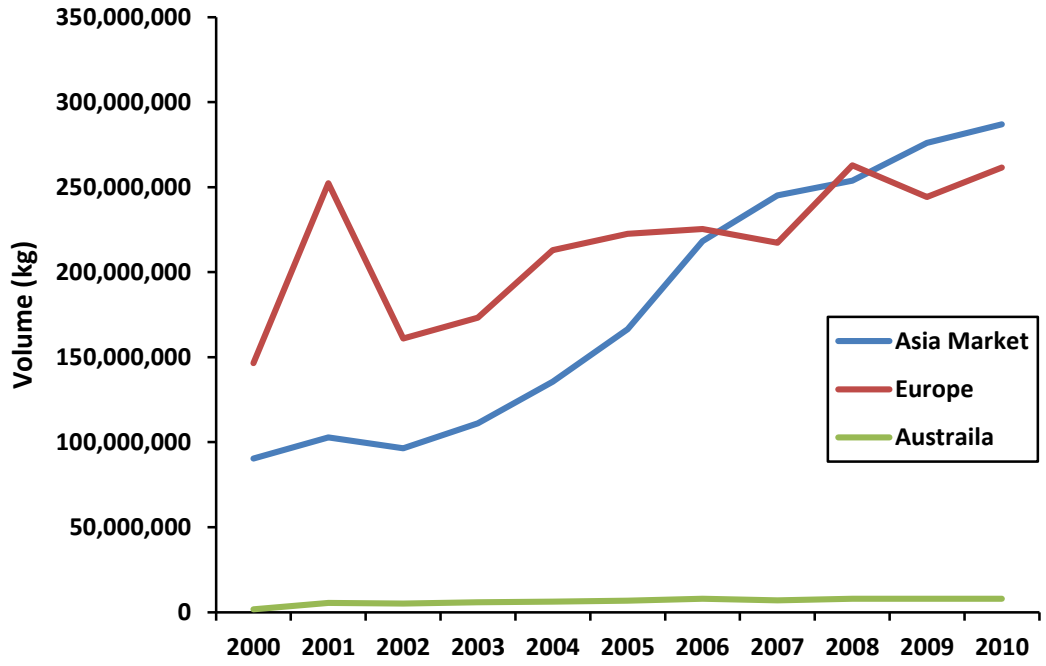

Figure 2.18 Growth in the volume of imports in the Asian, European and Australian Market for Infant Foods 2000-2010.

(Source: Calculations based on COMTRADE data)

Table 2.8 The upgrading performance 2000-2010 of Irish infant food products in Asia, Europe and Australia.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Asia	*Quadrant 2* PRODUCT UPGRADING
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Australia Europe 27	*Quadrant 4* PROCESS COMPETITIVENESS

Asia

Asia is the most valuable market for infant food imports from Ireland in terms of 2010 import values. The Asian import market was valued at US$2.1 billion in 2010. Ireland accounted for 12.3% of the total value of this market in 2010, a decline of 8.3% since the year 2000. As shown in Table 2.8, the upgrading performance of Irish infant food products in the Asian market, over the period 2000-2010, is failed product upgrading. Unit value is increasing relative to industry average over the period; however, Irish produce cannot sustain its market share as illustrated in Figure 2.19. This implies that although Irish dairy exporters are engaging in product innovation, they are not innovating as fast or faster than competitors and this is the reason products experienced a decline in market share.

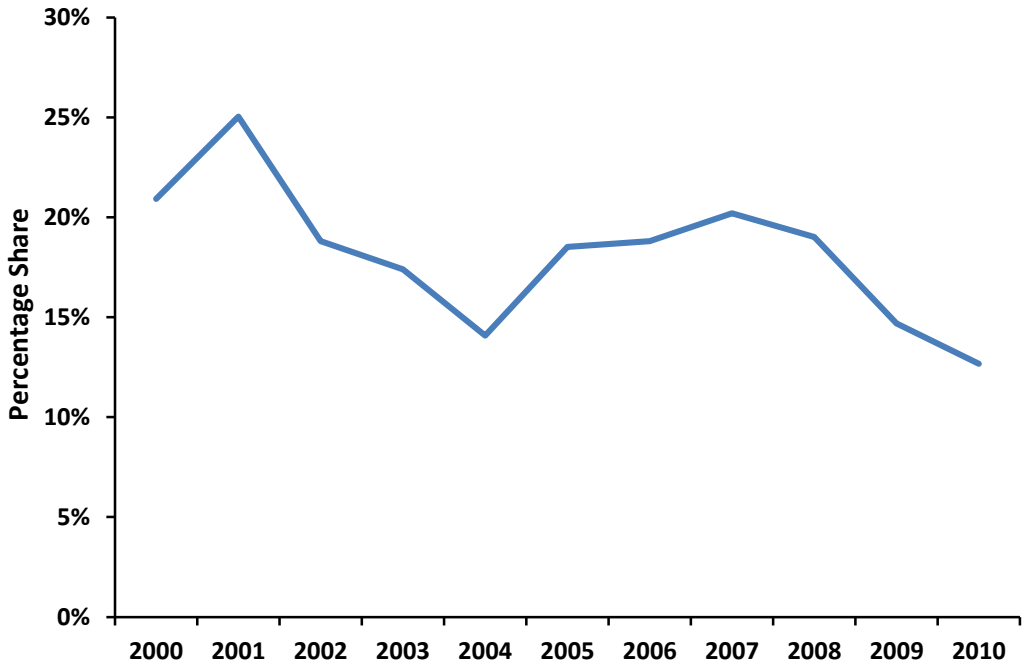

Figure 2.19 Ireland's Share of the Asian Import Market for Infant foods, 2000-2010. (Source: Calculations based on COMTRADE data)

High market growth rates, which are not accounted for in the upgrading framework, may also reflect Ireland's decreasing market share. This is shown in Figure 2.20. There is evidence of capacity constraints among infant milk formula companies located in Ireland. Danone's expansion in Macroom in 2011 trebled its processing capacity to 100,000 tonnes annually with 98% of this output exported (Ketch 2012). Furthermore, Danone Baby Nutrition continues its efforts to expand its production capacity in Ireland. In 2012, it was the effective under-bidder for Pfizer's infant formula business including a manufacturing plant in Ireland. Nestlé was successful in its bid for the business and subsequently has become the largest global producer of infant milk formula.

Figure 2.20 Percentage change in volume of imports sold on the Asia market and from Ireland 2000-2010.
(Source: Calculations based on COMTRADE data)

Europe

The second most significant market for Irish infant food products is Europe. The EU market, of which Ireland is a Member State, was used as a proxy for trends in the European market. Using this proxy, imports from Ireland in the European market are valued at US$254.5 million in 2010, accounting for 22.8% of total European imports. Imports from Ireland traded in the European market experienced product and process downgrading over the period 2000-2010. This implies that a reduction in the relative unit value of product was unable to increase market share.

Australia

The third most important market is Australia. In 2010, Irish infant food produce accounted for 58.5% of total Australian imports. This illustrates a decrease in market share of 10.4% since 2000. As shown in Table 2.8, infant foods imported from Ireland experienced product and process downgrading in the Australian market over the ten year period. Imports from Ireland experienced a fall in relative unit value over the ten year period. Although relative unit value was decreasing, Ireland could not sustain market share which decreased dramatically over the ten year period.

Comparative Analysis of Time Periods

There was a shift in the upgrading performance of Irish infant foods sold in the Asian and Europe markets over the two periods 2000-2005 and 2005-2010. In both markets, a rise in unit value suggests that product innovation activities were undertaken but failed to improve market share. The results of the analysis are presented in Table 2.9 and discussed below.

Table 2.9 Comparative innovation performance of Irish infant foods, across global markets, over the periods 2000-2005 and 2006-2010, valued at 2005 and 2010 prices respectively.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Asia (2006-2010) - $264.8m(2010) Europe (2006-2010) - $261.5m(2010)	*Quadrant 2* PRODUCT UPGRADING
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Europe (2000-2005) - $242(2005) Asia(2000-2005) - $145(2005) Australia(2000-2005) - $9.4m(2005) Australia(2006-2010) - $42m(2010)	*Quadrant 4* PROCESS COMPETITIVENESS

Asia

The sales of Irish infant foods almost doubled in the Asian market from $145m in 2005 to $264.8m in 2010. Over the period 2000-2005, Irish produce experienced product and process downgrading. However, during 2006-2010, the relative unit value was rising faster than the industry average, with total imports from Ireland valued at $265m. As market share continued to decline over the five year period the innovation performance is failed product upgrading.

Europe

In 2005, the European market was the most significant market for Irish infant foods valued at $242m. Over the period 2000 to 2005, the produce experienced product and process downgrading. From 2005 to 2010, the sales of Irish infant foods increased by €19.5m. However, the Kaplinaky and Readman (2005) analysis reveals failed product upgrading for the period 2006-2010. The rise in relative unit value of Irish product indicates that product innovation failed to improve market share.

Australia

The sales of Irish infant foods increased almost five fold in the Australian market from $9.4m in 2005 to $42 m in 2010. Over both time periods 2000-2005 and 2006-2010, the performance of Irish produce is categorised as product and process downgrading. Throughout the eleven years, Irish infant foods continue to lose market share in the market. Furthermore, reductions in the relative unit value accompanies falling market share.

2.6 Results: Upgrading Performance of Cheese

The COMEXT database reports that the EU imported 51 cheese product categories in 2010. The market was valued at €12 billion. Ireland exported produce under all 51 categories in that year, with a 4.8% share of the total value of the EU cheese import market.

The upgrading framework is applied to Irish cheese products that have at least a 1% share of the EU import market in 2010. The 1% market share cut off is necessary to make the analysis tractable, due to the high number of cheese product categories. Seventeen cheese product types from Ireland held 1% or more EU market share in 2010 with a total value of €548 million. Most notably, the Irish share of the EU market is relatively high in four categories: glarus herb cheese (48%); cheddar (45%); processed cheese (not grated or powder) (36%); and the product category that includes Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey (20%).

The upgrading results for each of the seventeen product categories are presented in this section. The results are displayed using product names, derived from the CN definitions listed on the COMEXT database and discussions with industry experts on trade data.

2.6.1 Performance over the period 2000-2010

Approximately 80% of the value of total Irish cheese exports, with at least 1% market share of the EU import market in 2010, is positioned in Quadrant 4. This is shown in Table 2.10.

Table 2.10 The upgrading performance of total Irish cheese exports in the EU market in terms of 2010 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING 0.73%	*Quadrant 2* PRODUCT UPGRADING 17.05%
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING 1.47%	*Quadrant 4* PROCESS COMPETITIVENESS 80.75%

For the seventeen cheese product types, three product categories experienced product upgrading. However, a high number of cheese categories (almost half) are positioned Quadrant 4 in Table 2.11, which suggests that process competitiveness is the leading trajectory of Irish cheese exporters. As mentioned earlier, it is assumed that process competitiveness reflects process innovation and not falling input costs or producer incomes. Most notably, three of the product categories in which Ireland has a high market share feature in this quadrant. They include glarius herb cheese[21]; cheddar; and the product category that Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey. Cheddar is Ireland's most valuable cheese export in 2010, valued at €327 million. Cheddar includes a family of types such as medium cheddar, mild cheddar, extra mature cheddar, vintage cheddar. The value of each type differs, for example vintage cheddar cheese is considerably more expensive that medium and mild cheddar types. In terms of performance, it experienced process competitiveness over the period 2000 and 2010.

[21] Type of grated or powdered cheese see Appendix A.3 for further details

Table 2.11 The upgrading performance of cheese product categories over the period 2000-2010.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Cream cheese Cheese of a fat content by weight of greater than 40%	*Quadrant 2* PRODUCT UPGRADING Mozzarella and cream cheese Type of grated or powdered cheese[22] Processed cheese (not grated or powdered) Emmentaler, Gruyère and Appenzell and Glarus herb cheese
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Blue-veined cheese and other cheese containing veins Gruyère and Sbrinz (excl. grated or powdered and those for processing) Jarlsberg (excl. grated or powdered and for processing) Fiore Sardo and Pecorino	*Quadrant 4* PROCESS COMPETITIVENESS Glarus herb cheese grated or powdered Type of processed cheese, not grated or powdered that differ based on fat content – *(1) Type of processed cheese, not grated or powdered that differ based on fat content – *(2) Emmentaler not grated or powdered or for processing Cheddar Product category includes Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey Hard grated cheese sold on the Greek market

*Notes: These products represent variants of a type of processed cheese that is not grated or powdered. For further information refer to product classification code in appendix A.3.

[22] CN trade classification code 040620 refers to all grated or powdered types of cheese

2.6.2 Comparative Analysis of Performance over Two Periods

Table 2.12 shows that approximately 71% of the value of all Irish cheese products, based on 2005 values, sold in the EU market is categorised as process competitiveness over the period 2000-2005. Seven product categories, including Ireland's most valuable cheese export, cheddar, are located within this quadrant. Furthermore, 20.3% of the value of all Irish cheese products, based on 2005 values, is located in quadrant two: product upgrading.

Table 2.12 shows that approximately 77.7% of the value of all Irish cheese products, based on 2010 values, experienced process competitiveness over the period 2006-2010. This is a 6.2% increase in the share of total imports from Ireland that experienced process competitiveness in the EU market, during the five year period 2000-2005. Furthermore, the number of products located in quadrant four has increased to nine since the previous analysis period. Table 2.12 also shows that 11% of the value of all Irish cheese produces, based on 2010 values, is categorised as product upgrading over the period 2006-2010. This is a decrease of 9% in the share of total imports from Ireland that experienced product upgrading since the period 2000-2005.

In relation to cheddar, there is no change in the performance of Irish product sold on the EU market over the two time periods. The relative unit value continues to fall as market share rises and the total value of cheddar imports from Ireland increases i.e. from €259.7m in 2005 to €327m in 2010. This suggests that Irish cheddar exporters are undertaking process innovation.

Table 2.12 The upgrading performance of cheese product categories over the period 2000-2005 in terms of EU 2005 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Cream cheese - €1.7m Sum: 0.4% of total value of cheese exports 2005	*Quadrant 2* PRODUCT UPGRADING Mozzarella and cream cheese - €79.4m Grated or powdered cheese excluding glarus herb cheese - €10.7m Blue veined cheese and other cheese containing veins - €0.5m Sum: 20.3% of total value of cheese exports 2005
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Hard grated cheese sold on Greek market - €14.1m Processed cheese (not grated or powdered), Emmentaler (not grated or powdered or for further processing) - €13.6m Cheese of fat content by weight less than 40% - €5.7m Emmentaler, Gruyere and Appenzell and Glarus herb cheese - €0.8m Product category includes Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey - €0.2m Glarus herb cheese grated or powdered - €0.2m Sum: 7.8% of total value of cheese exports 2005	*Quadrant 4* PROCESS COMPETITIVENESS Cheddar - €259.7m Similar to cheddar cheese but differentiated and considered a high value added product - €28m Type of processed cheese, not grated or powdered differs on fat content *(2) - €21.9m Type of processed cheese, not grated or powdered differs on fat content *(1) - €7.1m Fiore Sardo and Pecorino - €1.2m Gruyere and Sbrinz (not grated or powdered or for further processing) - €1m Jarlsberg (not grated or powdered and or for processing) - €8,140 Sum: 71.5% of total value of cheese exports 2005

*Notes: These products represent variants of a type of processed cheese that is not grated or powdered. For further information refer to product classification code in Appendix A.3.

Table 2.13 The upgrading performance of cheese product categories over 2006-2010, in terms of EU 2010 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Type of processed cheese not grated or powdered but differs by fat content *(1) - €7.3m Cheese of a fat content by weight of greater than 40% - €4.6m <u>Sum: 2.2% of total value of cheese exports 2010</u>	*Quadrant 2* PRODUCT UPGRADING Processed cheese (not grated or powdered) Emmentaler, Gruyere and Appenzell and Glarus herb cheese - €55.5m Product category includes Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey - €2.4m Jarlsberg (not grated or powdered and for processing) - €0.2m <u>Sum: 10.6% of total value of cheese exports 2010</u>
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Mozzarella and cream cheese - €27m Emmentaler (excluding grated or powdered and that for processing) - €14.7m Type of grated cheese or powdered cheese - €10.2m <u>Sum: 9.5% of total value of cheese exports 2010</u>	*Quadrant 4* PROCESS COMPETITIVENESS Cheddar - €327m Processed cheese not grated or powdered *(2) - €32.8m Similar to cheddar cheese but differentiated and considered high value added product - €35m Hard grated cheese - €17.2m Cream cheese - €4m Blue veined cheese and other cheeses containing veins - €3.5m Glarus herb cheese not grated or powdered - €2.5m Fiore Sardo and Pecorino - €2.5m Gruyere and Sbrinz (not grated or powdered or for processing) - €1.7m <u>Sum: 77.7% of total value of cheese exports 2010</u>

*Notes: These products represent variants of a type of processed cheese that is not grated or powdered. For further information refer to product classification code in Appendix A.3.

Agri-food industry reports and strategies emphasise the need for Irish dairy product exporters to shift production from commodity based products to value added products which receive high margins (Bell and Shelman 2010; Prospectus and Promar 2003). These higher margins arise from differentiated products, scarcity in supply and addressing the needs of consumers and customers. Value added cheese products are viewed as a driver of growth in mature dairy markets such as Europe. Government funded schemes such as the Dairy Investment fund (2007) and the Dairy Innovation Centre support changes to more value added products. The products featured in the category, namely Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey, are value added products according to industry experts. In terms of the EU market, Irish produce sold under this category was valued at €14.1 million in 2005 and €17.2 million in 2010. Comparison of the two time periods identifies an improvement in the upgrading performance of this product category over the period 2006-2010. Over the period 2000-2005, this product category experienced product and process downgrading. Over the period 2006-2010, the product category experienced product and process upgrading. This suggests that Irish exporters producing cheese produce under this product category are innovating faster than competitors and thus achieving higher prices and increasing market share in the late 2000s.

2.7 Results: Upgrading Performance of Butter

Eurostat's COMEXT database valued the EU import market at €2.7 billion in 2010. Imports from non-EU countries accounted for 3.82%, indicating that approximately 96% of all imports into the EU market were from Member States. In 2010, Ireland accounted for 17.9% of total EU butter imports. Over the specific time period of this analysis, Ireland exported ten butter product categories to EU. They included dairy spreads (three different types based on fat content), unpackaged natural butter, packaged butter, butter oil (a food ingredient), whey butter, recombined butter (not a consumer product), fats and oils derived from milk, and a high fat butter. As outlined in Table 2.14, approximately 72% of all Irish butter products, in terms of value, sold on the EU market in 2010 are positioned in Quadrant 3. Products such as unpackaged natural butter and a type of dairy spreads (containing no vegetable oils as substitutes) are located within this performance category.

Table 2.14 The upgrading performance of total Irish butter exports in the EU market, in terms of 2010 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING 0.7%	*Quadrant 2* PRODUCT UPGRADING 10.3%
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING 72%	*Quadrant 4* PROCESS COMPETITIVENESS 17%

2.7.1 Performance over the Period 2000-2010

In relation to product categories, there are good and bad performing products. Over the ten year period, three products traded on the EU market experienced product upgrading namely whey butter, recombined butter and a dairy spread type illustrated in Table 2.15. Furthermore, three product categories improved their process competitiveness over the ten year period. They are packaged natural butter, butter of a high fat content, and fats and oils derived from milk.

Table 2.15 The upgrading performance of butter product categories over the period 2000-2010.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(1) Butter oil (food ingredient)	*Quadrant 2* PRODUCT UPGRADING Whey butter Recombined butter (not consumer food) Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(2)
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Unpackaged natural butter Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(3)	*Quadrant 4* PROCESS COMPETITIVENESS Packaged natural butter Butter of a high fat content Fats and oils derived from milk

*Notes: These products represent variants of a type of dairy spread that is lower in fat than butter and contains no vegetable oil substitutes. For further information refer to the product classification code in Appendix A.4

2.7.2 Comparative Analysis of Performance over Two Periods

The location of the products across the performance categories differ when the analysis period is split into two, 2000-2005 and 2006-2010, as shown in Table 2.16. Over the period 2000-2005, 95.7% of the value of total butter exports, based on 2005 values, is located within quadrant 3, product and process downgrading. Six products are located within this quadrant.

Table 2.16 The upgrading performance of butter product categories over the period 2000-2005, in terms of EU 2005 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(2) - €4m Butter oil (food ingredient) €1.4m Sum: 1.6% of total butter exports 2005	*Quadrant 2* PRODUCT UPGRADING Recombined butter (not consumer food) - €0.3m Sum: 0.1% of total butter exports 2005
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Unpackaged natural butter packaging - €293.5m Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(3) - €272 Packaged natural butter - €25.9m Butter of a high fat content - €2.6m Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(1) - €1.3m Whey butter - €0.8m Sum: 95.7% of total butter exports 2005	*Quadrant 4* PROCESS COMPETITIVENESS Fats and oils derived from milk - €8.7m Sum: 2.6% of total butter exports 2005

*Notes: These products represent variants of a type of dairy spread that is lower in fat than butter and contains no vegetable oil substitutes. For further information refer to product classification code in Appendix A.4

As shown in Table 2.17, over the period 2006-2010 changes occur in the upgrading performance of five of the six product categories located in quadrant three over the period 2000-2005. Over the period 2006-2010, 27.6% of the value of total butter exports, in terms of 2010 values, is located across quadrants two and quadrant four indicating product upgrading and process competitiveness.

Table 2.17 The upgrading performance of butter product categories over the period 2006-2010, in terms of EU 2010 import values.

	Market share *decreases*	**Market share *increases***
Unit value *rises* relative to industry average	*Quadrant 1* FAILED PRODUCT UPGRADING Type of dairy spread, lower in fat than butter but no vegetable oil substitutes - €1.9m *(1) Sum: 0.4% of total butter exports, 2010	*Quadrant 2* PRODUCT UPGRADING Packaged natural butter - €37.1m Whey butter - €5.4m Fats and oils derived from milk - €0.3m Recombined butter (not consumer food) - €0.2m Sum: 15.7% of total butter exports, 2010
Unit value *falls* relative to industry average	*Quadrant 3* PRODUCT AND PROCESS DOWNGRADING Unpackaged natural butter - €353.2m Sum: 72% of total butter exports 2010	*Quadrant 4* PROCESS COMPETITIVENESS Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(2) - €44.7m Butter of with a high fat content - €12.1m Butter oil (food ingredient) - €1.5m Type of dairy spread, lower in fat than butter but no vegetable oil substitutes *(3) - €0.2m Sum: 11.9% of total butter exports 2010

*Notes: These products represent variants of a type of dairy spread that is lower in fat than butter and contains no vegetable oil substitutes. For further information refer to product classification code in Appendix A.4.

However, although there is movement in the product categories across the quadrants over the two time periods, 72% of the value of total exports in 2010 is categorised as product

and process downgrading over the period 2006-2010. This is attributed to one product type - unpackaged natural butter, valued in 2010 at €353.2 million. Kerrygold butter is a product brand of natural butter. Over the period 2000-2010, unpackaged natural butter is consistently Ireland's most valuable butter produce in the EU market in terms of total value. In 2000, the total value of product traded on the EU market was valued at €293.5 million rising to €353.2 million in 2010. However, the relative unit value and market share of unpackaged natural butter is decreasing over the periods: 2000-2005 and 2006-2010. Based on this, the product is categorised as product and process downgrading in both periods. The growth rate of the EU import market is not a contributory factor in the loss of market share (Figure 2.21). The growth in the volume of imports from Ireland explains the rise in the total value of unpackaged natural butter.

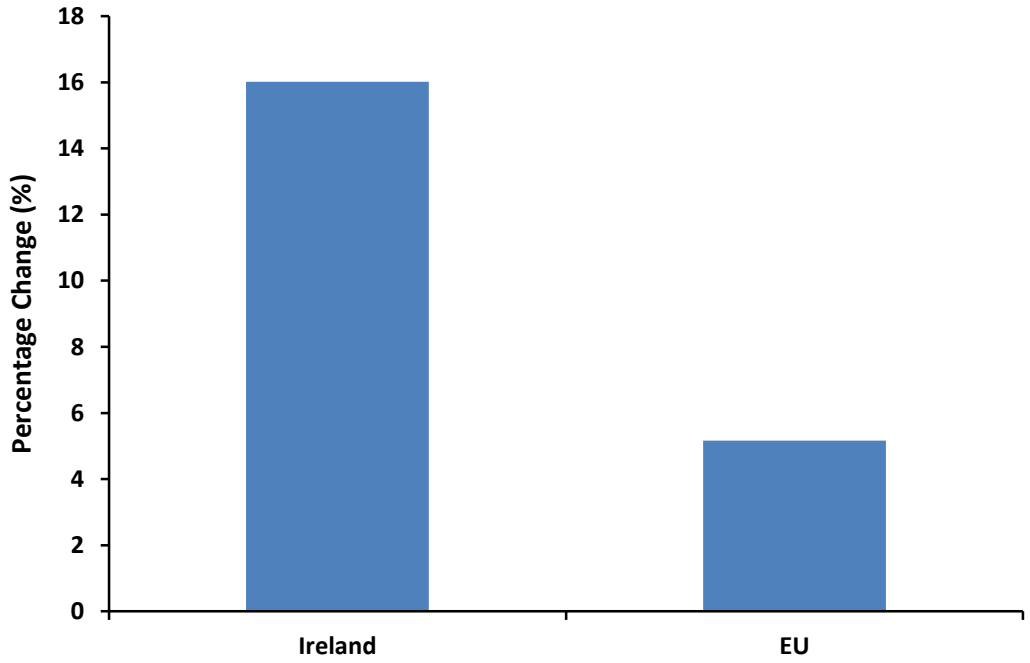

Figure 2.21 Percentage change in volume of imports from Ireland and total EU imports of unpackaged natural butter.

The fall in unit value over the ten year period may be attributed to intra-firm trade. This would imply that the unpackaged product produced in Ireland is no longer traded on the EU market; instead it is transferred by the Irish dairy exporters to foreign subsidiary firms. Based on discussions with two trade analysts from the Irish Dairy Board on the 2nd February 2012, it is apparent that unpackaged product is now, more than in the past, exported to subsidiary plants for packaging, primarily to Germany and Great Britain, and then distributed to markets across Europe. Figure 2.22 shows the gradual erosion of the Irish price premium for unpackaged natural butter relative to the EU average over the period. While in the year 2000, Irish producers received a price premium of 50% over the

EU average (rising to a height of 68% in 2003), the graph shows a rapid decline in the price premium received by Irish producers shrinking to 12% in 2009 before returning a negative price premium in the final year of analysis in 2010.

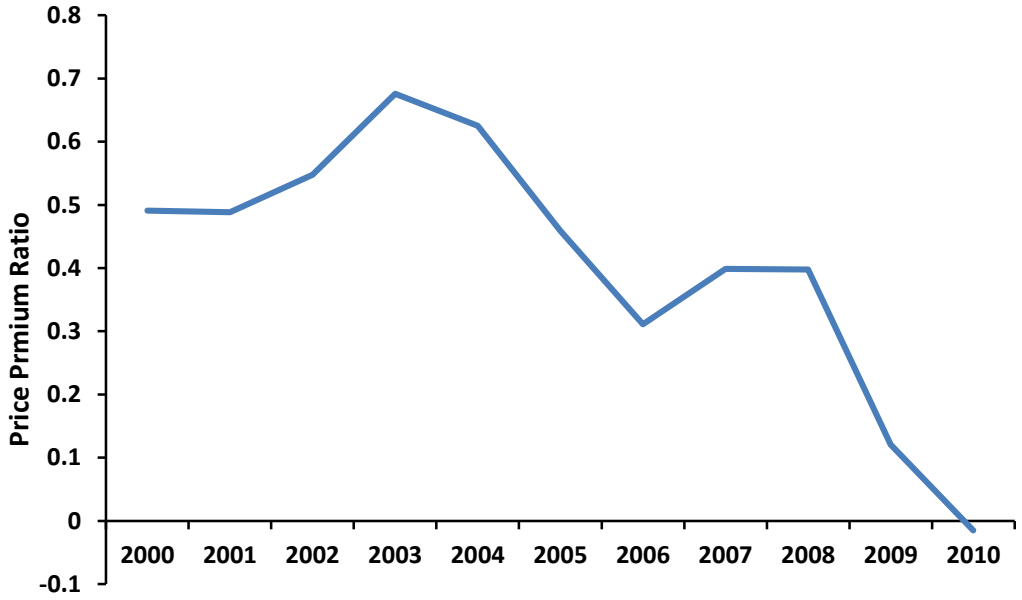

Figure 2.22 Irish price premium ratio for unpackaged butter relative to the EU market average over the period 2000-2010.
(Source: Calculations based on COMEXT data)

Packaged natural butter consistently obtains a €1 more per unit product than unpackaged product in the EU import market (Figure 2.23). Furthermore, in terms of the upgrading performance, packaged natural butter experienced product upgrading over the period 2006-2010. Both the relative unit value and the market share of Irish packaged natural butter increased over the five year time period, which illustrates a shift from product and process downgrading over the period 2000-2005. However, the total value of packaged natural butter trade (€37.1 million in 2010) is substantially less than the total trade value received for the unpackaged variety (€353.2 million in 2010).

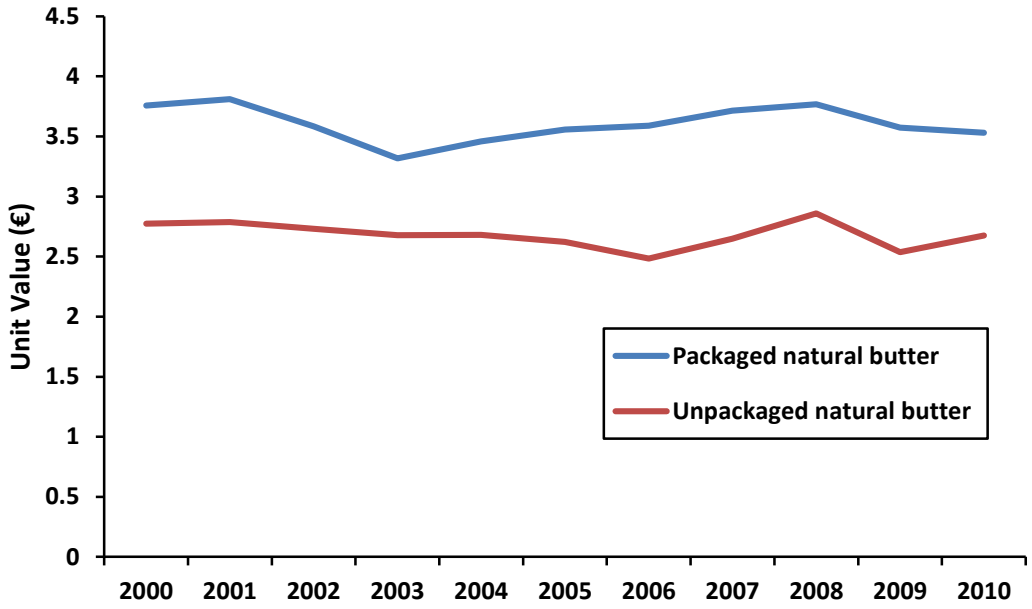

Figure 2.23 Unit value of natural butter, packaged and unpackaged over the period 2000-2010.

(Source: Calculations based on COMEXT data)

2.8 Discussion

Overall, there is evidence that Irish dairy exporters are engaging in innovative activity in particular over the period 2006-2010. However, although the relative performance across product categories differs, generally Irish dairy exporters are failing to innovate as fast as or faster than their global competitors. Thus, although the overall value of sales is increasing, Irish dairy exports are losing market share. As mentioned during the interpretation of the results, capacity constraint may be a factor limiting the capture of market share. The Kaplinsky and Readman framework does not account for this factor when analysing the results from their analysis. Thus, this shortcoming in their work is a contribution for this study.

The comparative analysis of periods 2000-2005 and 2006-2010, identifies improvements in innovation performance from 2005 to 2010 in a number of cheese and butter products that experienced product upgrading or process competitiveness. Although Irish exporters are engaging in product innovation activity over the time period they failed to innovate at a rate faster than competitors and this is the reason products experienced a decline in market share. The findings on the innovation performance for each of product categories, infant foods, cheese, and butter are discussed in the following paragraphs.

Infant foods

Infant foods are Ireland's most significant dairy product export in terms of total share of Irish dairy product exports in 2010. The upgrading analysis identifies that infant food imports from Ireland experienced a decrease in market share in the global market and more specifically the key markets of Asia, EU, and Australia, over the period 2000-2010. This is a concern for the Irish dairy industry, given that the analysis also confirms that infant foods are a high-growth sector in the Asian market. Irish product experienced product and process downgrading in the global import market over the period of analysis 2000-2010, which suggests relatively little innovation activity was undertaken in the period, as relative unit value is decreasing.

In the Asian market, the most significant market for Irish infant foods in 2010, failed product upgrading was identified suggesting that innovative activity reflected through a rise in unit value, failed to improve market share. This implies that although Irish dairy exporters are undertaking product innovation, they are failing to innovate at a rate faster than market competitors. As a result, Irish produce is unable to sustain market position in the Asian market. Furthermore, Asia is the fastest growing market for infant foods. Therefore, a potential reason for Ireland's loss in market share is the inability of Irish exporters' to meet the rising demands for imports due to constrained production capacity.

The issue of constrained capacity of manufacturers located in Ireland is identified through the increasing efforts of product manufacturers to increase their capacity for production.

Cheese

The findings also show that there is scope for a range of strategic positions among Irish cheese exporters trading on the EU import market. In terms of product upgrading, 17% of the value of total cheese imports from Ireland, experienced product and process upgrading, in terms of 2010 values. Overall, the findings suggest that the focal position is process innovation. Over the period 2000-2010, 77% of the value of total cheese imports from Ireland, in terms of 2010 values, experienced process innovation. Cheddar, consistently Ireland's most valuable cheese export, is one of the products that experienced process innovation.

Butter

The study revealed that 72% of the total value of butter exports is accounted for by products that have experienced both product and process downgrading. Furthermore, one product category primarily accounted for this - unpackaged natural butter. There are three possible reasons for its poor innovation performance over the period 2000-2010:

- product or process innovation activity did not take place
- price reduction strategies were unable to sustain market share
- intra-firm trade between Irish exporters and their subsidiary packaging plants in destination markets.

The latter reason is more likely to explain the poor innovation performance of Irish unpackaged natural butter on the EU market. The consultations with industry analysts revealed that unpackaged butter produce is primarily sent to subsidiary packaging plants of exporters in Europe (Great Britain and Germany). Therefore, the low product prices relative to industry average may reflect intra-firm trade. Overall, the data sources suggest that the butter sector in Ireland is constrained in terms of packaging capacity. This is of significant importance to the Irish dairy industry. There is on average, a €1 difference per price of product finished in Ireland versus product that is packaged in a European destination.

2.8.1 Limitations of this Study

As detailed in section 2.4, there are two broad categories of limitations with using the Kaplinsky and Readman (2005) framework. The first category relates to the assumptions underpinning the framework of product homogeneity and the equating of market share gains only with process efficiency. The second category relates to the specific contextual

complications in its application to the dairy industry arising from CAP supports and profit switching transfer pricing (pstp). This can bias the measures derived from the trade data.

The international trade statistics do not distinguish trade between two unrelated parties and intra-firm trade. Detecting pstp in trade data ideally requires firm level information on intra-firm trade (Bonturi and Fukasaku 1993). To determine whether or not pstp exists and, if it does, whether it has changed over the period in question the strategy applied in this study has two components. First, the GHM index is calculated to identify whether vertical intra-industry trade exists in a sector and thus the likelihood of the existence of pstp. This is supplemented with information gained from interviews with industry experts to gauge their opinion on whether in their opinion pstp does exist and the relative importance of pstp in the product categories. Second, when using the Kaplinsky and Readman (2005) framework it is important to identify if the extent of pstp has changed over time as if it has not then it does not necessarily impact on the interpretation of the implied innovation performance identified in the analysis. The indicator used to proxy the extent of pstp in this study is the ratio of GDP to GNP.

The highest level of disaggregation available for infant milk formula across all trade data sources is 'food preparations for infant use'. Therefore, the trade data cannot differentiate between types of infant food products or the nature of products in terms of finished or unfinished. This has the effect of masking underlying causes for the findings of relative innovation performance on Irish produce on global markets. More specifically, finished products are more likely to receive a higher product price than unfinished products thus distorting the average unit value measures used in the analysis.

2.8.2 Future Work

The first area for future work is a case study on each of the international infant food companies located in Ireland to supplement the upgrading analysis in this study. A multiple case study design could explore and compare the innovative practices in terms of the nature and level of innovation undertaken in their Irish based plants. The sector comprises of three foreign multi-national companies: Abbott Nutrition, Danone Baby Nutrition and Nestlé. Collectively the case studies could enrich the upgrading analysis and also provide new insight to the industrial organisation of the infant food sector in Ireland.

The second area for future work is to analyse the impact of innovation activity on the competiveness of the agri-food sector relative to other industrial sectors using export and

patent data. There is evidence of correlation between innovative activity and export performance (Montobbio and Rampa 2005). The number of patents issued to Irish dairy companies is a measure of innovation output. This would require sourcing data on patents relating to the agri-food sector granted by the Irish Patent Office and export trade data from the Central Statistics Office, Ireland.

The third area for future work is to examine the practice of profit switching transfer pricing within the Irish dairy industry to complement a similar study undertaken on certain chemical and food products in Stewart (1989). In addition to trade data, the research study would require data on value added and profitability of MNCs that locate subsidiaries in Ireland.

2.8.3 Contributions

This study contributes new findings on the relative innovation performance of Irish dairy products on global markets, more specifically, on Ireland's most significant dairy products: infant foods, cheese, and butter. Innovation is important for improving the competitiveness of Irish dairy exports in global markets. There are good and bad innovation performers across the product categories. Furthermore, across product categories there is scope for improvement. Although Irish dairy exporters are engaging in innovation activity, the analysis suggests that generally they are failing to innovate as fast as or faster than global competitors

Second, this study contributes to a better understanding of one of the tools available for measuring innovation from trade data. It identifies two contextual complications when applying the Kaplinsky and Readman (2005) framework to an agricultural context of market supports and profit switching transfer pricing that need to be considered. The framework can only be robustly calibrated for the latter, if firm level data is available for incorporation into the analysis.

Third, this study contributes to an understanding of how the industrial organisation of the Irish dairy industry is reflected in trade data measures. Using the highest level of disaggregation available, the study identified the competitors, significant markets and the sales performance of infant foods, cheese, and butter exports.

2.8.4 Implications for Policy

The inability of the Irish dairy exporters to innovate as fast as or faster than their global competitors presents an opportunity to improve the speed of the innovation process. Programmes that support collaboration among the dairy exporters could provide a mechanism to achieve this. Although they are competing on global markets, collective engagement in activities such as research and development could improve the time taken to deliver product and process innovation. The strategy of simultaneous cooperation and competition is referred to as co-opetition (Bell and Shelman 2010). Achieving co-opetition among Irish dairy exporters provides a way to undertake innovation activity at a rate faster than global competitors to improve unit value and market share of Irish exports on global markets.

The constrained capacity experienced by the dairy exporters in terms of production has implications for the ability of the sector to respond to the rising global demand for dairy products. Government investment to support the expansion of production facilities would address this. The findings of this study emphasise the need to support expansion in both processing and packaging facilities of Irish dairy exporters, to increase the volume of finished products exported from Ireland for trade on the global market. Furthermore, the expansion of production facilities will increase the capacity of the Irish sector to process the 50% increase in milk supplies expected in 2020, post abolition of the EU milk quota in 2015.

2.9 Conclusion

This study measured the innovation performance of Irish dairy products using international trade data. Growth in the Irish dairy industry is reliant on sustaining and improving competitiveness in their export markets. The analysis in section 2.3, of Irish dairy exports over the period 2000-2010, establishes infant foods, cheese, and butter as Ireland's most significant dairy product exports. This provided the rationale for examining the innovation performance, of each of these products, in the global market. To assess the innovation performance of these products over the time period, the framework developed in Kaplinsky and Readman (2005) was applied. In this framework, relative unit value and market share are used as an indicator of relative innovation performance. The study contributes new findings on the innovation performance of Irish dairy exports and the industrial organisation of the Irish industry reflected in the trade data. The findings conclude that product innovation is evident across the three product types – infant foods, cheese, and butter. However, the rate of innovation compared to global competitors is an issue. This presents an opportunity for policy measures to improve the speed of the innovation process occurring in Irish dairy exporters and their subsequent value chains.

In recent years, programmes requiring collective action among dairy product manufacturers and their suppliers have been developed to support product and process innovation to improve the quality of Irish dairy products. This includes programmes such as CellCheck which works to improve the quality of milk supplies, Food for Health Ireland which works to develop new products and product ingredients and Origin Green the national sustainability programme working to promote Ireland's green image among global customers. These programmes provide alternative ways to improve the innovative capacity of the industry and its stakeholders. In Chapter 3 and 4, the mechanisms of innovation brokering and systemic instruments are explored as alternative ways to supporting successful improvements in the innovative capacity of the Irish dairy industry.

3 Establishing Part Time Innovation Brokers to Orchestrate Problem Focused Innovation

3.1 Introduction

Innovation is now recognised as a networked activity (Lundvall 2007; Fagerberg 2006; World Bank 2006; Smits and Kuhlmann 2004). In the network literature, a new subject is the idea of intermediaries whose commercial goals are to bridge linkages across structural holes to facilitate the co-development of innovation (Klerkx and Leewuis 2009a; Lomas 2007; Howells 2006; Burt 2004). The focus of this study is on a specific type of intermediary that is concerned with brokering interactions for innovation, so called innovation brokers. The few research studies in this area are based on innovation brokers in SME networks (Batterink et al. 2010), the construction sector (Winch and Courtney 2010) and the agricultural domain (Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a; Klerkx and Leeuwis 2009b). These studies have provided an overview of the types (Klerkx and Leeuwis 2008b) and functions (Klerkx and Leeuwis 2009a; Winch and Courtney 2007) of innovation brokers, how they are organised and embedded within an innovation system (Klerkx and Leeuwis 2009a; 2009b) and how they successful orchestrate innovation networks (Batterink et al. 2010). The aim of this study is to understand how part time innovation brokers operate and in which conditions they function most effectively, to provide insight into the question posed in Winch and Courtney (2007). The focus on part time innovation brokers is deliberate. As although recognised in the literature, the research on innovation brokers has been limited to full time innovation brokers (Batterink et al. 2010; Klerkx and Leeuwis 2009a; Klerkx and Leeuwis 2008a). This is a concern given that innovation brokers are chosen based on the existence of their social networks across structural holes thus, in many cases they are already members of the network through their occupational role. Therefore, the selected individual must undertake the innovation brokering role on a part time basis. This type of innovation broker faces the additional responsibility of managing the mixed identity in an

effort to maintain credibility as an independent, third party member of the network (Klerkx, Hall and Leeuwis 2009).

Using a case study approach, this study explores the activities of seven part time innovation brokers within the national mastitis programme, *CellCheck*. Semi-structured interviews, observations and secondary data analysis are employed to identify the practices and environmental arrangements that influence how these innovation brokers, whose goal is to optimise the demand and supply of mastitis control information to reduce the incidence of mastitis, span the structural holes across farm networks. The documented practices and arrangements are used to develop propositions for supporting newly established part time innovation brokers.

The empirical findings show that the practices chosen are based on the experimental nature of the role, prior context analysis, historical experience, existing organisational connections, and programme guidelines. These findings, in addition to others on the environmental arrangements that enable and constrain the fulfilment of the brokerage role, highlight four propositions for supporting part time innovation brokers. They include promoting synergies between occupational and innovation brokerage roles, prior analysis of context and demands of the full time role, the subsequent development of templates for unfamiliar activities and the establishment of a peer networking group.

The study is structured as follows: The first section (3.2) reviews the literature on network brokering with a specific focus on the functional roles of an innovation broker. Section 3.3 gives an overview of the empirical context. This details the market problem of milk quality in the Irish dairy value chain and the national approach to addressing it, namely CellCheck. The network activity to address mastitis control at farm level is presented as a problem focused innovation system. Section 3.4 outlines the research questions for the study. Section 3.5 contains the methodology. The study's findings are presented across two sections. Section 3.6 presents the findings on the activities associated with newly appointed part time innovation brokers. Section 3.7 presents the findings on the environmental arrangements that enable and constrain the fulfilment of the brokerage role. In section 3.8, the findings are discussed and assessed to generate four propositions for supporting part time innovation brokers and the contributions of the study are outlined. Lastly, section 3.9 concludes the study.

3.2 Literature Review

From the viewpoint that innovation is a network activity, innovation is the product of a collective endeavour undertaken by a group of people who share a common goal (Meinzen-Dick and Di Gregorio 2004). Communication gaps so called structural holes within a network cause weak levels of knowledge exchange (Lomas 2007; Burt 2004). These gaps in the social structure of the network can hamper collective action in terms of communication, coordination and problem solving between actors (Burt 2007; Dodds, Watts and Sabel 2003). Structural holes provide an opportunity for a broker to build communication linkages within the network (Burt 2008a; 2008b; 2007; 2004) by accessing the type of interactions needed for innovation in a given situation i.e. analytical or interpretative (Lester and Piore 2004). In the paradigm of an innovation system, an individual or organisation that undertakes a brokering role in the innovation process is termed an '*innovation broker'* (Batterink et al. 2010; Winch and Courtney 2007). Winch and Courtney (2007, p751) define an innovation broker,

'*acting as a member of a network of actors in an industrial sector that is focused neither on the generation nor the implementation of innovation but on enabling organizations to innovate'.*

As previously noted in Chapter 1, the role of an innovation broker is broader than that of information brokering discussed in Burt (2008a; 2008b; 2007; 2004) and Lomas (2007). It extends beyond improving information use for decision making to create an enabling environment for effective policy formulation and implementation, development and innovation (Klerkx et al. 2012; Fisher 2011).

Functions of an Innovation Broker

Three generic functions of an innovation broker, agreed in the innovation brokering literature, are demand articulation, network formation and innovation process management (Batterink et al. 2010; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a). The first function, demand articulation, refers to the activities undertaken to identify, understand and articulate the problems and needs of clients within the innovation network to inform network formation and innovation process management activities. The second function, network formation, denotes scanning and scoping suitable actors for the network and building and negotiating relationships between the actors. The successful construction of interactions between actors requires the development of a common language between actors (Lester and Piore 2004). The third function, innovation process management, refers to efforts to sustain interactions and alignment between the heterogeneous (in relation to type and institutional backgrounds) actors to ensure networks are sustained and productive (Klerkx and Leeuwis 2009a).

The practices used to fulfil an innovation brokering role are characterised as experimental in nature (Klerkx and Gildemacher 2012; Klerkx and Leeuwis 2008b). This facilitates a process of 'learning while trying' on what works within a specific innovation system (Klerkx and Gildemacher, 2012; Klerkx, Hall and Leeuwis, 2009). This process can facilitate change in a broker's practices as the needs of actors within the innovation system evolve. Furthermore, operating within the context of an evolving innovation system such as a problem focused innovation system, the role set out for an innovation broker may change over time or become obsolete if the problem is resolved (Anandajayasekeram and Gebremedhin 2009; Klerkx and Leeuwis 2008b).

In addition to experimentation, the literature also distinguishes the practices used by an innovation broker to fulfil the role as a function of the specific broker's understanding and judgement of the innovation system within which he/she is embedded (Klerkx and Gildemacher 2012). Factors that influence these practices include the phase of development, composition of the innovation system and the strength of relations between the actors (Madzudzo 2011; Winch and Courtney 2007; World Bank 2006).

Differentiating Innovation Brokers: Full Time and Part Time

The innovation brokering literature differentiates between full time and part time brokers (Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a; Winch and Courtney 2007; Howells 2006). However, the literature provides no evidence to suggest one type of innovation brokerage function is more successful than the other (Winch and Courtney 2007; Howells 2006; van Lente et al. 2003). Full time innovation brokers, also known as specialised innovation brokers, undertake the role as their core occupation. In the Dutch agricultural sector, empirical studies have primarily focused on specialised innovation brokers (Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a). This type of broker can be purposefully established or may develop from existing intermediary organisations. For part time innovation brokers, the brokerage role is not their primary role; it is a side activity (Klerkx and Leeuwis 2009a). Klerkx, Hall and Leeuwis (2009) identify existing organisations such as funding and research agencies in developing and emerging countries operating as part time innovation brokers. Within the agricultural domain, a number of scholars have suggested that existing organisations such as agricultural extension agencies may find it difficult to undertake a full or part time brokerage role (Klerkx and Gildemacher 2012; Devaux et al. 2009; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a). The issue is that the traditional role of an agricultural extension agent in building bilateral linkages between researchers and farmers is to transfer research to the farmer whereas the role of an innovation broker is to facilitate

knowledge exchange by building multiple linkages between a diverse range of actors (Klerkx and Gildemacher 2012; Klerkx, Hall and Leeuwis 2009).

3.2.1 Establishing an Innovation Broker

The focus of this research study is on the establishment of a part time innovation brokerage function to address the problem of coordinating interactions for problem focused innovation. In this section, the broad literature that informs the establishment of brokers within a network and/or innovation system is reviewed. More specifically, the literature reviewed informs the rationale for establishing an innovation brokerage function, the parties suitable for undertaking the role, approaches to positioning an innovation broker within an innovation system and the tensions to embedment. It is evident from the literature review, that although there is a differentiation between full time and part time innovation brokering, empirical studies undertaken to date have examined full time innovation brokers (Klerkx, Hall and Leeuwis 2009a; Winch and Courtney 2007).

Klerkx, Hall and Leeuwis (2009, p30) argue that a brokerage function can emerge '*purposefully or serendipitously'* within an innovation system. In both cases, a number of factors which are not mutually exclusive can influence the decision. They are as follows:

- To stimulate innovation by addressing suboptimal levels of interactions among actors (Klerkx, Hall and Leeuwis 2009a; Winch and Courtney 2007; Lester and Piore 2004),
- To aid interactions for problem solving and prevent market and innovation system failures,
- To avail of public funding and/or the financial opportunity for a broker (Klerkx, Hall and Leeuwis 2009; Burt 2004),
- The availability of an individual or organisation with network connections that bridge the structural holes which can help establish new linkages for resources in the system (Klerkx and Leeuwis 2009a; Burt 2004)
- To support alternative types of innovation such as entrepreneur driven innovation or social innovation (Klerkx and Leeuwis, 2009a).

In the case where an innovation brokerage function purposefully emerges, Klerkx and Gildemacher (2012) emphasise the importance of context analysis. This involves diagnosing the strengths and weaknesses of the innovation system in which the innovation broker is being embedded. This can include the presence and capabilities of actors, the level and type of interactions, the institutions and the enabling infrastructure.

An innovation brokerage role can be executed by individuals or organisations such as research or extension personnel or organisations or government agencies (Klerkx et al. 2012). These criteria for choosing individuals or organisations to undertake an innovation brokerage role draw on the requirements for technology brokers set out in Kolodny et al. (2001). These criteria centre on choosing entities that are visible and accessible, have access to appropriate sources of knowledge and information, have the ability to respond to the request of clients, and can complement the weaknesses of clients.

An innovation brokerage function addresses structural holes at various levels of an innovation system which depend on the system focus: macro (e.g. national), meso (e.g. regional or sectoral) or micro (e.g. farmer or individual) level (Ekboir 2012). For example, in the Dutch agricultural sector Klerkx and Leeuwis (2009a) identify innovation brokers operating at alternative levels. These include innovation consultants who are concerned with addressing the needs of individual and groups of firms (including farms); peer network brokers who target the formation and maintenance of peer networks; and systemic brokers who focus on higher levels of innovation system aggregation such as national innovation systems. Systemic brokers can be identified as a type of systemic instrument. They focus on supporting system innovation by addressing weak interactions within an innovation system. To realise their goal, they focus on improving relations between actors and establishing favourable institutions which influence actors' interactions (Klerkx and Leeuwis 2009a). Systemic instruments are discussed further in Study 3.

Burt (2004) places an emphasis on selecting personnel that possess social networks across structural holes as they are familiar with the alternative ways of thinking and behaving that exist across the actor groups. Furthermore, the innovation brokering literature places an importance on choosing personnel that are detached from the existing actor groups, to help establish credibility and enable the innovation brokers to act freely to fulfil their role (Klerkx et al. 2012; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2008a). It is deemed that a not-for-profit status promotes innovation brokers as independent and objective in their role (Winch and Courtney 2007).

However, embedding an innovation brokerage function as an independent third party position, presents a number of tensions relating to neutrality, function overlap and funding (Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009b). The literature outlines two ways to address these challenges: publicly funding activities of innovation brokers and setting out a limited mandate. Based on their study of innovation brokers in the Dutch agricultural sector, Klerkx and Leeuwis (2009a; 2008a) are advocates of public

funding agencies supporting innovation brokering, as its impact can be difficult to measure thus, making it difficult to monetarily valuing it. For example, the effectiveness of network design activities, such as demand articulation and network formation, is difficult to measure (Batterink et al. 2010). In addition, support from publicly funded agencies may enhance the neutrality of innovation brokers in their on-going management of the innovation process. Winch and Courtney (2007) concluded, from their analysis of full time innovation brokers in the construction sector, that in general innovation brokers have elements of public funding. However, the literature identifies potential drawbacks to public agencies funding the activities of innovation brokers. The drawbacks include justifying public expenditure on innovation broker activities that are difficult to measure, the potential of innovation brokers lobbying government interests due to financial dependency, and the inability of innovation brokers to develop a mandate that is different to traditional intermediary services such as extension agents in the agricultural sector (Klerkx and Gildemacher 2012; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a).

Outlining a limited mandate for the innovation brokerage function is important for overcoming function ambiguity relative to existing organisations, within the innovation system. In addition, making a decision on the permanent or temporary nature of the role is important to prevent functional ambiguity and measurability issues of the impact of innovation broker activities (Klerkx and Leeuwis 2009a). In the next section, the empirical setting for this study, the Irish dairy industry and the national mastitis control programme, CellCheck, are outlined. The programme applies a network approach to address the market problem of milk quality in the Irish dairy industry. The network of regional coordinators established to collectively fulfil an innovation brokering function within the programme is the focus of this research study.

3.3 Milk quality in the Irish Dairy Industry

3.3.1 The Market Problem

Ireland is a large producer of milk relative to its population size. For this reason, the dairy industry is highly dependent on export markets. In recent years, milk quality has been recognised as a rising market problem for the Irish dairy value chain. Furthermore, in light of the projected rise in milk production by 50% by 2020 (as projected by Department of Agriculture Fisheries and Food (2010a)) and the increasing demand for dairy products in global markets, milk quality has been identified as one way to improve the competitiveness of the Irish dairy industry (Devitt et al. 2013; More 2009).

Milk quality covers criteria relating to composition (e.g. butterfat, protein, milk solids) and hygiene (total bacteria count and somatic cell count). According to More (2009) somatic cell count (SCC) is "*the most important single indicator of milk quality*". SCC reflects the health status of the mammary gland and is used as an indicator of milk quality in national and international regulation of milk quality. A healthy udder quarter requires SCC less than 100,000 per millilitre (m/L) of milk, higher levels are indicative of the presence of mastitis (More 2009). In general a SCC level of 200,000 cells per m/L is accepted as an indicator of the presence of mastitis (International Dairy Federation 1997). Mastitis is inflammation of the mammary gland and usually caused by bacteria entering the teat canal and moving to the udder. The bacteria multiply and cause a mastitis infection which results in an inflamed udder. Mastitis causing bacteria can originate from two factors (CellCheck 2011): other cows, which spread bacteria causing contagious mastitis; the environment, which harbours bacteria which cause environmental mastitis (CellCheck 2011). The cow's immune response to the infection results in a localised influx of inflammatory cells seen as an increase in the SCC of the milk in that quarter (CellCheck 2011). From October 1, 2010 all milk produced and imported in the European Union must come from farms with average SCC under 400,000 cells per millilitre of milk.

Mastitis control has been identified as a problem for the Irish dairy industry. At farm level, Kelly et al. (2009) identified a range of farm SCC levels using a random sample of 400 farms from 82,209 to 773,028 with the median 282,887 cells per millilitre of milk. The data for the Kelly et al. (2009) study on milk volume and bulk tank SCC on a collection basis was supplied by the relevant dairy processor for the time period 2000-2007. Furthermore a more recent Teagasc study, Geary et al. (2012) estimated the economic loss associated with mastitis on Irish farms. In addition to the reduction in milk quality at farm level, mastitis produces other costs relating to reduced milk yield,

treatment of disease or culling, discarded milk and penalties. Net farm profitability was calculated by Geary et al. (2012) based on farm receipts minus farm costs, and mastitis costs were indicated by various ranges of Bulk Milk Somatic Cell Count (BMSCC). For a 40 hectare farm, Geary et al. (2012) found that as BMSCC (presence of mastitis) increased net farm profitability decreased. The net farm profitability results of the study are illustrated in Table 3.1.

Table 3.1 Effect of mastitis on net profits of Irish dairy farms.

BMSCC ($x10^3$/mL)	0-100	100-200	200-300	300-400	400+
Net farm profit €	31,252	26,771	19,661	16,936	11,748

Source: Geary et al. (2012)

At dairy processing level in addition to milk quality, high SCC levels cause low product yield, reduced shelf life and flavour change (Geary et al. 2012). The dairy processors are increasingly setting incentives and penalties to encourage low SCC levels as mastitis is also a substantial cost for the processing sector. In this study, the term dairy processor is used to refer to an organisation (which may have a cooperative structure) undertaking milk processing activities to produce a mix of dairy products to include milk, cheese, butter and milk powders.

3.3.2 CellCheck

A national approach towards improving milk quality is being coordinated by Animal Health Ireland (AHI). AHI is an industry led, government supported body concerned with the control of non-regulatory diseases in Ireland. AHI represents a partnership approach to animal health, bringing together livestock producers, processors, advisors, and the Irish government. AHI was established in 2009 and all the partners have committed to financial support for a period of five years (More et al. 2010). The activities of AHI centre on supporting the industry partnership to improving herd health (Animal Health Ireland 2012c). The agricultural stakeholders involved in AHI are listed in Figure 3.1.

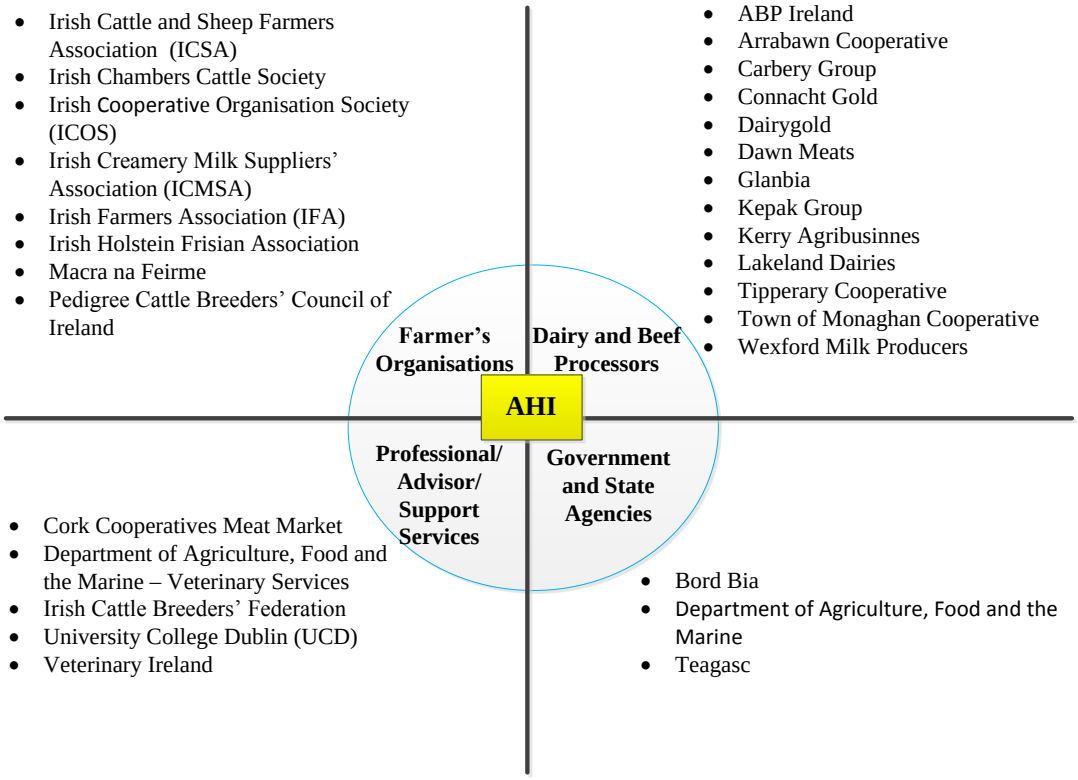

Figure 3.1 AHI stakeholder groups 2012.
Source: AHI (2012b)

A Delphi study undertaken by AHI with farmer and industry stakeholders helped prioritise non-regulatory disease issues in the Irish beef and dairy industries based on factors such as cost, impact, international perception and impediment to international success (Animal Health Ireland 2012c). From this, AHI prioritised Bovine Viral Diarrhoea, udder health/milk quality and Johnes disease and Infectious Bovine Rhinotracheitis.

CellCheck is the national programme to improve milk quality programme set out and coordinated by AHI. The objective is to enable the dairy industry maintain a national

average bulk milk somatic cell count of 200,000 cells millilitres or under by 2020 (Animal Health Ireland 2013a). The programme is delivered in partnership with industry stakeholders. The CellCheck model is based on a number of mastitis control programmes most notably the Australian CountDown DownUnder, the American MilkMoney and the Dutch Udder Health Centre programme (Kennedy 2011). CellCheck works to achieve its objective by empowering farmers to take responsibility for mastitis control on their farms.

The science behind CellCheck is not new (McCoy 2012a). The knowledge, science and skills to address somatic cell count in milk already exist. Therefore, CellCheck rationalise the milk quality problem as a failure to bring best practice on mastitis control into use on farms. To address this, CellCheck implement a new approach to disseminate and encourage use of best practice (McCoy 2012c). This action is described as '*a new approach to tackling an old problem*' (CellCheck Technical Working Group 2012; McCoy 2012c; CellCheck 2011) and involves applying a team based approach to disseminate information on mastitis control. €uromilk, a pilot programme run by Teagasc and a major dairy processor in November 2008, influenced this approach (McCoy 2012d). €uroMilk centred on creating a communication network that facilitated service providers to work together as a team with the farmer. Multidisciplinary teams were created to lead farm-specific mastitis control programmes on 23 Irish dairy farms. The impact and effectiveness of these teams in influencing change on participating farms was assessed to determine if this model of delivery would be a feasible solution to address the national problem. The findings revealed the positive impact multidisciplinary teams had on increasing awareness of mastitis among farmers and service providers (McCoy 2012d). Euromilk improved farmer understanding of the link between high SCC and economic costs which in turn increased farmer demand for evidence based information on mastitis control from their dairy service providers (McCoy 2012d). These findings are consistent with the view that innovation, defined as the process of technical change, is a network activity involving multidisciplinary stakeholders (Fagerberg 2006; World Bank 2006). More specifically, these findings show that innovation is a function of both analytical and interpretative interactions among actors in a multidisciplinary network (Lester and Piore 2004).

The success of CellCheck is based on industry stakeholders working together. An improvement in milk quality requires changes in farmer practices on mastitis control. There are two levels at which stakeholders work together: the organisation level and the farm level (Kennedy 2011). At the organisation level industry partners represent farmers, processors, service providers and government, for example, the Irish Farmers Association, Veterinary Ireland, the Irish Milk Quality Cooperative Society (IMQCS),

Teagasc and the various dairy processors. The industry partners are involved in the planning and development of the programme through the Technical Working Group, Industry Consultation Group and the Social Science Steering Group.

At farm level, the national dairy landscape is divided into seven regions. In each region, representatives from the industry partners form a network. These networks comprise of local agricultural service providers and farmers. The agricultural service providers include veterinary practitioners, milking machine technicians, farm advisors and milk quality advisors from dairy cooperatives, and/or dairy processors. The activities of the network focus on the development, diffusion and use of mastitis control information at farm level. These activities, to bring information and practices on mastitis control into use on farms, are conceptualised in this study as a problem focused innovation system as illustrated in Figure 3.2.

The self-organisation of local actors to address a problem which they are unable to resolve individually can be viewed as an organisational regime, which involves the collective exploration of an identified problem and the potential ways to resolve it, previously discussed in the work of Sabel and Simon (2012) and Sabel and Zeitlin (2012; 2008). The network processes are experimental in nature and as actor learning occurs the networks evolve (Sabel and Simon 2012). The interactive process is characterised in Lester and Piore (2004) as analytical i.e. rational problem solving.

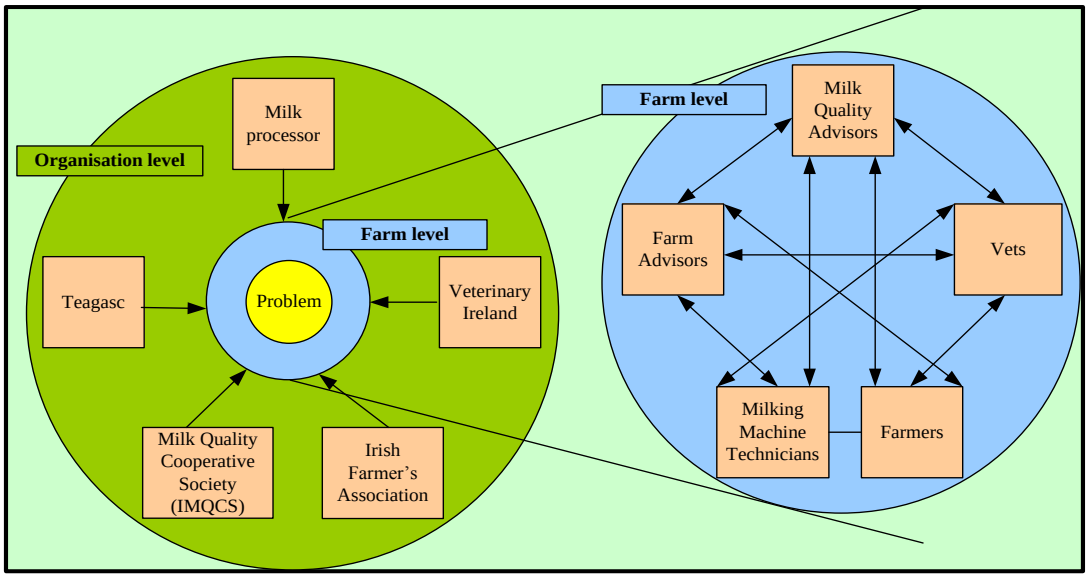

Figure 3.2 CellCheck approach to addressing milk quality.

The three elements of the CellCheck programme are farm guidelines for mastitis control, service provider training and farmer workshops (CellCheck Technical Working Group 2012). Published in early 2012, CellCheck mastitis control guidelines entitled *Farm Guidelines for Mastitis Control* were developed by the Technical Working Group as a management and advisory tool for service providers and farmers. The guidelines are science based and include best practice recommendations on mastitis control drawing on Countdown Downunder resources.

Based on the value of a team based approach identified in €uromilk, CellCheck works on developing the capacity of local service providers so they can jointly deliver training and support to farmers (Animal Health Ireland 2012b). The service providers which include veterinary practitioners, milking machine technicians, farm advisors and milk quality advisors are trained together. This is to ensure the individual actors disseminate the same consistent message on mastitis control to farmers (McCoy 2012c) and also to provide them with the skills to work as part of a multi-disciplinary group that jointly delivers workshops to farmers. Figure 3.3 illustrates the three stage training schedule presented at CellCheck Focus Group Meeting June 27th 2012. The training schedule illustrates that in addition to an analytical approach, CellCheck creates a public space for actors to engage in open-ended conversations that adapt to changes in the context of the CellCheck programme. This addresses the work of Lester and Piore (2004) and the importance of interpretation in addition to analysis for innovation.

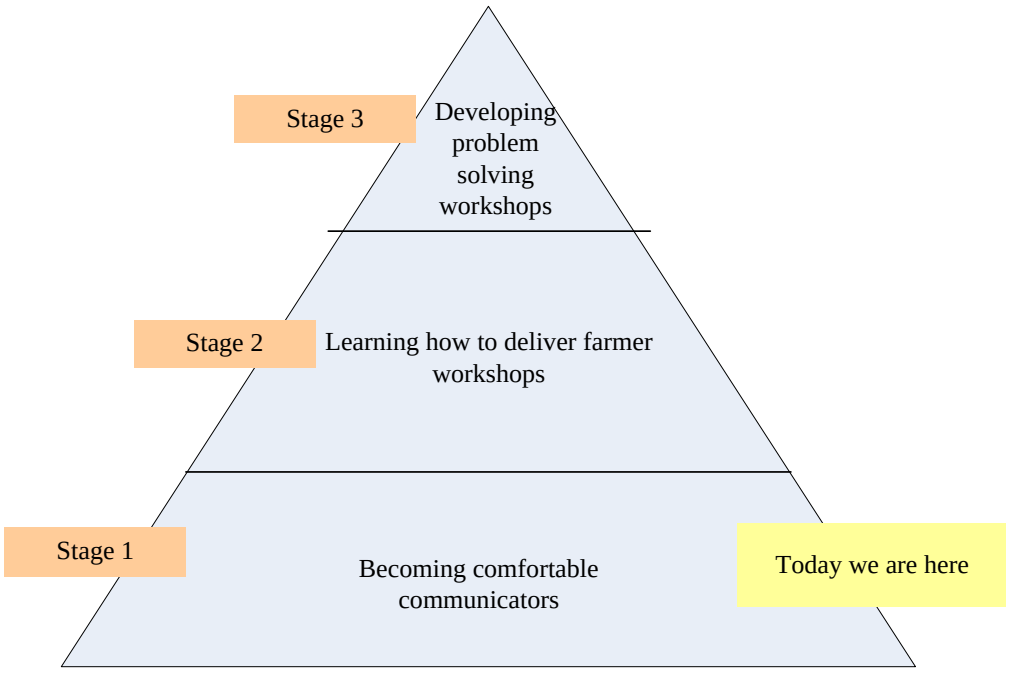

Figure 3.3 The training schedule of local service providers in CellCheck.
Source: Presented at CellCheck focus group 27th June 2012

The goal of Stage 1 training seminars was to build awareness of the CellCheck programme among dairy service providers. The training session was focused on promoting the use of the CellCheck Farm Guidelines among service providers, as they are in a position to advise farmers on mastitis control as part of the work duties. By the end of June 2012, approximately 500 multi-disciplinary service providers completed Stage 1 training. Eleven seminars were conducted nationwide. This included four '*sweeper*' seminars conducted for service providers who were unable to attend the first round of seminars. Service provider participation was even across all the disciplines – veterinary practitioners, farm advisors, milking machine technicians and dairy processor/cooperative personnel. The results from the feedback forms distributed after seminars stated attendees found the seminar useful and 75% of the attendees expressed interest in attending Stage 2 training to learn about how to start delivering farmer workshops (McCoy 2012b). Post completion of Stage 2 training a service provider can deliver a farmer workshop once arranged with the local regional coordinator (Animal Health Ireland 2013b). The final stage of service provider training, yet to be conducted at time of writing, relates to equipping personnel with the resources (skills, knowledge) to work in partnership to problem solve farm specific mastitis problems.

Farmer workshops are used to disseminate the mastitis control information, outlined in CellCheck farm guidelines. They are convened on farm and can be arranged using existing farm discussion groups[23] or outside of a discussion group format (Animal Health Ireland 2013b). The farmer attendance fee is €30. The delivery of a farmer workshop requires four presenters; a facilitator, veterinary practitioner, milking machine technician and co-operative/processor milk advisor.

The first phase of farmer workshops is concerned with informing all farmers (regardless of farm SCC levels) about mastitis control. The planned second phase of workshops will deal with specific mastitis control problems on farms. Therefore, CellCheck adheres to changing the content of workshops overtime as change occurs in the mastitis control needs of farmers. This change is monitored by CellCheck using analytical interactions with national records on SCC levels[24] and through interpretative interactions with farm service providers and farmers. Eventually, workshop content is expected to shift its focus from mastitis control to problem-solving specific mastitis cases.

[23] The discussion group format refers to an organised group of farmers who meet regularly (on average once a month) on a host farm to see, discuss and learn about new practices and technologies that could be applied on their farms . Discussion groups are usually facilitated by a farm advisor (public or private). They can involve embarking on a farm walk, sharing experiences, assisting each other in problem solving or examining activities on the host farm. In 2009, Teagasc dairy advisors facilitated 250 discussion groups (Hennessy and Heanue 2012).

[24] Collected on an on-going basis by the Irish Cattle Breeding Federation and milk processors

3.3.3 Problem Solving at Farm Level

In early 2012, the CellCheck farm guidelines were published, delivery of Stage 1 service provider training was almost complete and pilot farmer workshops involving approximately 100 farmers had been completed (McCoy 2012b) The next challenge to be addressed was to provide trained service providers with opportunities to interact with farmers by creating and sustaining levels of engagement. On 21st March 2012, the author attended a CellCheck Social Science Steering Group[25]. At this meeting, the members[26] conversed on establishing a coordinating body to build connections to facilitate interactions between the trained service providers and farmers. After the meeting, the following questions were left unanswered:

- How can CellCheck create and sustain engagement between service providers and discussion groups i.e. for the delivery of farmer workshops?

- How can CellCheck encourage engagement between service providers and farmers that don't participate in discussion groups, with the objective of improving awareness and best practice?

- How can CellCheck encourage engagement or contact between service providers and farmers that require farm-specific problem solving including follow-up?

- Do coordinators have a role to play in any of these scenarios?
    - If so, what is the extent of that role?

- Who should the coordinators be i.e. milk processors or representatives, CellCheck, farm advisors, veterinary practitioners or practices?

The next CellCheck Social Science Steering Group meeting was held on May 31st 2012, which the author also attended. During the meeting, it was clear that CellCheck had recognised the need for a coordinating body and had selected nine individuals to undertake the roles. The following month, the team was reduced to seven when two personnel opted out of the role. The personnel selected are full time employees of a dairy processor, located in Ireland. They fulfil their coordinator role in CellCheck on a part time basis. CellCheck named them regional coordinators. Each was tasked with the responsibility to build and maintain linkages between trained service providers and farmers within their local dairy region (Figure 3.4).

[25] A research group established in 2011 to guide the social science component of CellCheck
[26] The group members included a sociologist, , a Teagasc economist, chairman of the CellCheck technical working group, a strategic planning expert and CellCheck project manager

Figure 3.4 Geographical locations of seven CellCheck regional coordinators.
Source: Animal Health Ireland[27]

During the Social Science Steering Group meeting on 31st May 2012, the programme manager revealed that the decision to select all the regional coordinators from the dairy processing sector was influenced by a similar action in CountDown DownUnder. In this programme, the responsibility for information dissemination through organised interaction was transferred to the processing sector, post development of mastitis control tools and knowledge. CellCheck also allocated this role to personnel from the dairy processing sector, based on the existing networks they work in, their recognisable face within their region and their potential to act as a regional access point for farmers and service providers to become involved with CellCheck. These criteria share similarities with the work of Burt (2004) on information brokering to bridge structural holes in that the choice of personnel is those that are located close to the structural holes. Burt (2004) places emphasis on selecting personnel that possess social networks across structural holes as they are familiar with the alternative ways of thinking and behaving that exist across the actor groups. Using the conceptual framework of a problem focused innovation system, a regional coordinator is depicted in Figure 3.5 as a broker. This brokerage

[27]Available from http://www.animalhealthireland.ie/page.php?id=155, last accessed 15th February 2013

function purposefully emerged to coordinate the collective action among the dairy service provider and farmer participants in CellCheck by improving interactions between them.

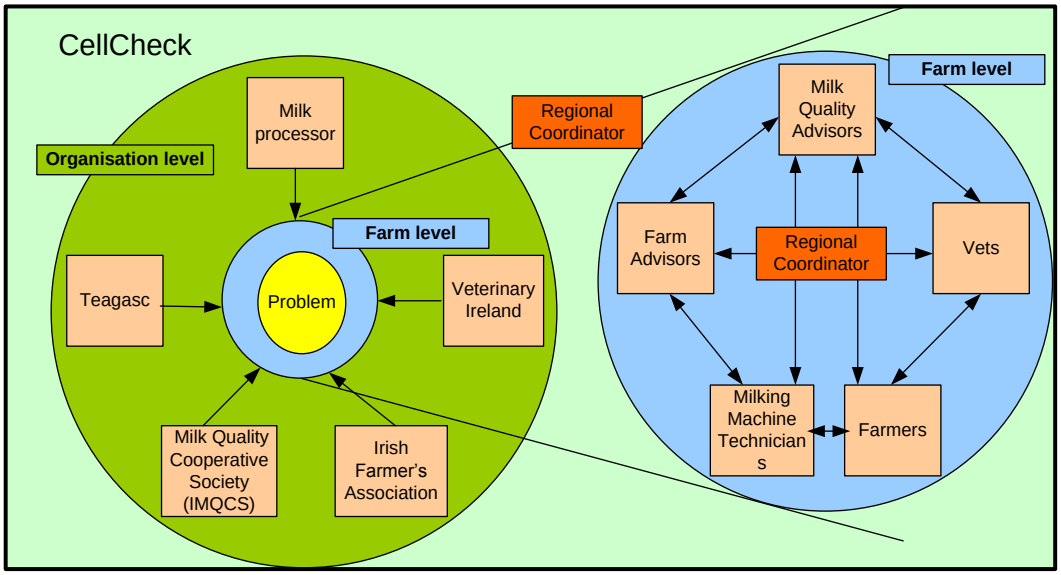

Figure 3.5 Role of regional coordinator in constructing regional networks in CellCheck.

Due to the evolving nature of CellCheck, the activities of the regional coordinator are continuously changing. During the Social Science Steering Group meeting on May 31st 2012, CellCheck broadly outlined their activities. These included continuously scanning and selecting appropriate service providers (representatives from the industry partners in CellCheck) and farmers[28] to form regional networks and building and sustaining linkages between the service providers and farmers to facilitate knowledge flows and learning.

Based on the CellCheck rationale for establishing regional coordinators and their evolving role in CellCheck, the author identifies the collective role of all the regional coordinators in CellCheck as innovation brokering. Previous studies on innovation brokering emphasise the evolving and unpredictable nature of the role (Batterink et al. 2010; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a). This is due to on-going changes within the innovation system, such as actors' needs, interactions and the problem sequence, in which the innovation brokerage function is embedded thus the role adapts accordingly.

[28] This includes discussion group members, non-discussion group members, and problem farms in terms of high SCC levels

Although the role of the regional coordinators had been set out, uncertainty surrounded how CellCheck could support them in fulfilling their role. AHI required information along the following trajectories:

- the practices of the regional coordinators to fulfil their role
- the specific arrangements that could be considered to support the regional coordinators in the implementation of their role
- These information requirements formed the basis for developing the research questions and the methodological approach taken in this study.

3.4 The Research Question

This study focuses on the activities of the seven part time innovation brokers in CellCheck. The intent is to gain insight into the practices and environmental arrangements that enable the regional coordinators fulfil their role, to provide measures to support part time innovation brokers.

As previously mentioned, the literature principally focuses on the activities of full time innovation brokers known as specialised innovation brokers (Batterink et al. 2010; Klerkx and Leeuwis 2009a; Klerkx and Leeuwis 2008a). This is a concern given that part time innovation brokers face an additional responsibility of managing their mixed identities in effort to maintain neutrality and credibility (Klerkx, Hall and Leeuwis 2009).

The work of Lester and Piore (2004) and Burt (2004) provide understanding on the types of interactions in CellCheck and the brokerage opportunities to bridge communication gaps between the various actors at farm level. However, their work can provide little guidance to CellCheck on supporting the newly appointed regional coordinators. This body of work does not address support mechanisms for active brokers whose role is characterised as continuously adapting to changes within the innovation system. In particular, Burt (2004; 2007) study of information brokerage occurs in static networks and thus is limited in its ability to explain activities of active agents.

Therefore, the research undertaken in this study is informed by previous findings relating to the establishment of an innovation brokerage function. This involves the positioning of an innovation broker within an innovation system (Winch and Courtney 2007; Kolodny et al. 2001), the functions undertaken to fulfil an innovation brokerage role (Batterink et al. 2010; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a) and the tensions that arise when embedding an innovation broker (Klerkx and Leeuwis 2009b).

The central research question asked in this study is *how might part time innovation brokers be supported in their role?* To address this, the activities of the regional coordinators in CellCheck are examined to identify the practices of the regional coordinators and the environmental arrangements that support them and propose new recommendations on supporting the establishment of part time innovation brokers.

To identify the practices of the regional coordinators and the environmental arrangements that support them in their role, three generic functions of an innovation broker, agreed upon in the literature, guide the inquiry as follows:

- *Relating to demand articulation: How do the regional coordinators identify and assess the needs and problems of regional stakeholders?*
- *Relating to network formation: How do the regional coordinators scan, scope, filter and select network participants?*
- *Relating to innovation process management: How do the regional coordinators enhance alignment and maintenance of the network*?

The first step of the inquiry investigates the activities of the regional coordinators to understand the diverse needs of the sources and users of mastitis control information within their specific region. This is an important task for the regional coordinator as it informs their approach to create and sustain regional networks. The second step of the inquiry explores the practices used by each regional coordinator to scan and select stakeholders to form their regional network. These networks provide the resources to fulfil CellCheck activities such as farmer workshops and future problem solving specific farm cases. The third step in the inquire investigates the activities of each of the regional coordinators to align the supply and demand for mastitis control information within their regional networks which is an on-going task.

3.5 Methodology

The purpose of this research is to provide new recommendations on supporting the establishment of part time innovation brokers. The aim is to identify arrangements that enable part time innovation brokers fulfil their role. Given the sparse literature on part time innovation brokers and the rationale outlined, an in-depth analysis, rich in contextual detail is required. Similar to other studies on innovation brokers such as Winch and Courtney (2007) and Batterink et al. (2010), this study employs a case study approach. This includes document analysis, observations and semi-structured interviews with seven innovation brokers to identify the practices of the innovation brokers to fulfil their role. A priori, the practices of the regional coordinator to fulfil the role are evolving. This implies that the role adapts to changes occurring within the environment in which they are embedded. To capture the evolution in the part time innovation broker activities, the practices of the regional coordinators are examined at two points in time, six months apart. A number of methods were employed to include:

- A review of documents and observations of CellCheck events to explore the roles and responsibilities of the regional coordinators as innovation brokering
- Interviews with the regional coordinators about their practices concerning the fulfilment of their role in CellCheck.

3.5.1 Regional Coordinators as Innovation Brokers

In this section, the role of the regional coordinators in CellCheck is confirmed as part time innovation brokering. Document analysis and observations were used to collect data on the emergence of the regional coordinator function in CellCheck. This data was collected over the period May 2012 to October 2012. Table 3.2 outlines the methods used.

Table 3.2 An overview of the data collection and analysis undertaken to confirm regional coordinators as innovation brokers.

Data collected for the study	**Analysis approach**
Document review: - CellCheck programme documents such as business plans and progress reports and - CellCheck articles published in the farming press were reviewed to trace the efforts to establish and support the regional coordinators	Document analysis was used to: - define the rationale for establishing a coordinating function and the responsibilities associated with the role - verify names, organisations and farming and service provider practices mentioned during interviews and observations - provide additional detail to support information from interviews and observations
Observations: - CellCheck programme and training events (Appendix B, Table B.1) involving farm level stakeholders were observed to record information on the implementation of innovation brokerage function in CellCheck	Researchers notes were examined to: - define the functions and responsibilities associated with the role - monitor evolution in responsibilities

The findings confirm that the context in which this inquiry of innovation brokering takes place is not different from that reviewed by other innovation brokering studies. The findings confirm that the practices to fulfil the regional coordinator role in CellCheck are not predefined, by the programme coordinator, AHI. AHI set out broad guidelines, but the practices used to fulfil the role are open to the interpretation of regional coordinator. For example, although AHI set out guidelines on selecting participants to form the regional networks, they are not mandatory. The findings are presented in more detail below. First, the rationale behind establishing the regional coordinating function is discussed and compared to the theoretical formulation of an innovation brokerage function. Second, the reasons for selecting representatives from the dairy processing sector are outlined. Lastly, the functions outlined for the regional coordinators are compared to those outlined in the literature for innovation brokers.

Rationale for Establishing Regional Coordinators in CellCheck

As previously stated, in May 2012 seven individuals from the dairy processing sector undertook a regional coordinator role in CellCheck. This role is undertaken on a part time basis. Their principal occupation is with the dairy processor. The rationale for CellCheck to establish a coordinating function at regional level is '*to increase the organisational capacity of the CellCheck team*', stated by the CellCheck programme manager in the AHI newsletter in July 2012. At the National Dairy Conference 2012, the CellCheck programme manager describes the regional coordinators as '*a local point of contact and information on the CellCheck programme, and to coordinate farmer workshops along with local service providers'*. The reasons for establishing a regional coordinator network are comparable with those detailed in Klerkx and Leeuwis (2009a) based on their analysis of innovation brokers in the Dutch agricultural sector. Table 3.3 details the similarities.

Table 3.3 Comparing rationales to establish regional coordinator network and an innovation brokerage function.

Reasons for establishing a regional coordinator	**Reasons for establishing an innovation broker**
Build a network of specialist expertise on mastitis control	New linkages for resources
Educate farmers on mastitis control	Support innovation through support of training
Coordinate interactions between trained service providers and farmers	Stimulate innovation
Continuous work to build a network of skilled multi-disciplinary service providers as a resource for problem solving specific mastitis cases	Facilitate a level of interaction for problem solving

Embedding Regional Coordinators in the Irish dairy landscape

The activities of the regional coordinators are funded by their affiliated milk processor. This addresses one of the three tensions to embedding an innovation broker previously discussed in section 3.2.1. As an industry partner, the dairy processing sector agrees to finance the activities of regional coordinators as part of their commitment to the delivery of the CellCheck programme. The findings confirm that in addition to addressing the potential of a funding tension, issues of neutrality and functional ambiguity were also addressed when selecting individuals to undertake the regional coordinator role.

During the Social Science Steering Group meeting on 31st March 2012, the CellCheck programme manager stated the importance of selecting personnel that are perceived by farmers and dairy service providers as neutral. Relative to other dairy stakeholders the dairy processing sector is viewed as neutral. Unlike milking machine technicians, veterinary practitioners and Teagasc advisors they are not selling their services at farm level. On the contrary, they are the buyers of farm produce.

The potential for functional ambiguity was also thought through before choosing dairy processor representatives. This relates to a lack of clarity for the regional coordinators and dairy stakeholders on the difference between CellCheck duties and dairy processor duties. However, the observed events of a CellCheck focus group meeting on 27th June 2012 and a farmer workshop on 7th October 2012 confirms that regional coordinators undertake CellCheck duties independent of the dairy processors' interests. The objective of the regional coordinating function is to build and maintain regional networks comprising of local service providers and farmers to facilitate the flow of mastitis control information. They are not directly involved in the creation or delivery of the information. They are concerned with building linkages between farmers and service providers to facilitate these activities. This confirms that each of the regional coordinating function is a third party, independent actor in CellCheck, the innovation system. Furthermore, the data analysis confirms that the innovation brokering role which the regional coordinators undertake within the regional networks is independent from that of other dairy processor representatives.

Responsibilities and Role

During the CellCheck Technical Working Group Meeting on 27th June 2012, the functions for the regional coordinators in CellCheck were outlined. The functions share similarities with those outlined for the coordinators in CountDown Downunder programme (Brightling et al. 2009; Brightling et al. 2005). The role of the regional coordinators in CellCheck is to connect information sources (service providers) and users (farmers) of mastitis control information. To facilitate this, the activities outlined for them include:

- ensuring programme activities and information are formatted to address regions' needs, organising programme events in regions,
- building stakeholder networks (farmers and service providers),
- promoting the programme and its activities within the region with the use of local media to raise the profile of the programme, and
- providing regional feedback for programme evaluation.

These activities share similarities with the theoretical functions of an innovation broker listed in Table 3.4.

Table 3.4 Identifying the activities outlined for the regional coordinators as generic functions of an innovation broker.

Regional coordinator activities	**Contribution to CellCheck**	**Innovation broker function**
Addressing the needs of regional farmers and service providers on mastitis control	CellCheck perceived as active at local level	Demand articulation
Build regional networks comprising of farmers and service providers to participate in CellCheck activities	Organisation of farmer workshops Bridge skilled farmers and service providers and for farm specific problem solving	Network formation
Promoting and sustaining stakeholder engagement with the programme and ensuring continuous alignment between the sources and users of mastitis control information	Promote stakeholder engagement with CellCheck Local point of contact for information on CellCheck Provide feedback on programme	Innovation process management

3.5.2 Interview Data: Collection and Analysis

The findings from the document analysis and observations confirmed first, that the regional coordinators as innovation brokers and second, that the approach to carrying out the role is not predefined but open to the interpretation of the regional coordinator. Three functions of an innovation broker are used to examine the practices of seven part time innovation brokers. Two interviews were conducted for each case. The role of the interviewer was to ask, listen and interpret the experiences of the interviewee (Mason 1996). The role of the interviewee was to reflect and give explanations about what they did and currently do and why (Polkinghorne 2005). The interviews were undertaken approximately six months apart. The profile of the interviewees is outlined in Table 3.5. The first set of interviews was conducted face-to-face. The second set of interviews was conducted by telephone. Both sets of interviews took the form of a conversation and involved mostly open ended questions to elicit views and experiences from the interviewees on the fulfilment of their role. Table 3.6 gives an overview of the data collection and analysis undertaken.

Table 3.5 An overview of the characteristics of the regional coordinators.

	Role in dairy processor	**Farm Workshops Run by Interview 1**	**Farm Workshops Run by Interview 2**
RC1	Sustainability manager	1 (13 farmers)	1 + 2 with agricultural students (45 farmers approximately)
RC2	Mastitis control expert	0	12 (160 farmers approximately)
RC3	Milk quality/ Dairy advisor	0	0 + no interview
RC4	Farm advisor	1 (10 farmers)	2 + 2 as section in a discussion group meeting (60 farmers approximately)
RC5	Milk quality/ Dairy advisor	0	0 + no interview
RC6	Agri-business manager	0	18 (300 farmers approximately)
RC7	Milk quality/ Dairy advisor	1 (20-25 farmers approximately)	7 (100 farmers approximately)

Table 3.6 An overview of the collection and analysis of interview data for this study.

	Data Collected	**Analysis Approach**
Interview One September and October 2012	Discussions with the regional coordinators were recorded and transcribed to define the practices to fulfil their role	Within case analysis: The activities were examined to define the practices and roles to produce a detailed account for each regional coordinator Cross case analysis: The cases were compared to develop a general explanation that fits with each of the individual cases
Interview Two April 2013	Follow up discussions with the regional coordinators six months after first interview to identify: Evolution in the practices used The enablers and/or constraints to fulfilling role	Within case analysis: The activities were examined to identify: change in the practices and roles for each regional coordinator arrangements that enable or constrain fulfilment of role Cross case analysis: The cases were compared to define arrangements associated with supporting role

The following data collection steps were taken:

- An interview schedule was drawn up, based on the theoretical functions of an innovation broker (Appendix B). This was used as a guide during the first set of interviews, conducted in September and October 2012. Six of these interviews were digitally recorded and transcribed verbatim. Each audio was organised into a single profile document. One interviewee requested the interview not be recorded so short hand notes were taken during the interview and later written up to produce the seventh profile document.
- The second set of interviews was undertaken in April 2013. The seven regional coordinators were contacted, first by email and then by telephone, to partake in an interview. Five of the interviewees agreed to partake and allocated a day and time that suited them. During this time, spring 2013, Irish dairy farmers faced a forage crisis. This crisis increased the workload associated with the regional coordinator's core occupation in the dairy processor. For this reason, two of the regional coordinators declined partaking in a follow-up interview. In light of these pressures, the author decided to conduct all interviews by phone. The questions asked were guided by the innovation broker functions and the findings from the first interviews. The interview schedule is set out in Appendix B. The conversations lasted approximately 30 minutes and were not digitally recorded. Notes were taken by the researcher including direct quotations of interviewees' comments on relevant topics.

The following data analysis steps were taken:

- The transcripts from the first set of interviews were analysed individually to capture the detail of each case. The transcripts were examined to produce a series of descriptive labels under each research question, which were then clustered to develop category labels. Next; the category labels across the cases were compared. Pairs of cases were selected (Eisenhardt 1989) to capture a list of similarities and differences between the cases. A review of the series of categories developed an argument of how the regional coordinators fulfil their role.
- The transcripts from the second set of interviews were analysed individually and then the findings were compared across the cases.

In the next section, the findings from the cross case analyses are presented. The findings are divided into two sections. The first section, Section 3.6 Findings: Applied Practices presents the practices and roles assumed by the regional coordinators to fulfil the three innovation broker functions. This is followed by Section 3.7 (Findings: Enabling and Constraining Arrangements) which presents findings on the arrangements that enable and constrain the fulfilment of the role.

3.6 Findings: Applied Practices to Fulfil Role

The practices used to fulfil the regional coordinator role in CellCheck are open to the interpretation of the individual regional coordinator. The findings confirm that over the six month period, these practices evolve. Specific developments relate to the way the regional coordinators' form their regional network and sustain participants' engagement with CellCheck. For example, the approach of two regional coordinators (RC1 and RC4) to engaging with farmers during network formation evolved over the six month period. Post identifying the farmers, the two regional coordinators now write to the farmers specifying farm specific information on the cost of mastitis. This approach is used to encourage and sustain participation in CellCheck activities.

In the following section, the findings on the practices used to articulate demands of stakeholders, form regional networks and promote and sustain stakeholder engagement with CellCheck are discussed under the theoretical innovation broker function headings – demand articulation, network formation and innovation process management. Next, in section 3.6.4, the five themes that emerge from the data concerning the practices used by the regional coordinators to fulfil their in CellCheck are discussed. They include experimental, organisational connection with dairy processor, historical experience (interpretation of needs) and AHI guidelines.

3.6.1 Demand Articulation: Needs and Problems

The regional coordinator is concerned with understanding the needs and problems of regional stakeholders relating to mastitis control. This relates to the sources and uses of mastitis control information. The regional coordinators adopt a number of practices to understand the needs and problems of farmers and service providers relating to mastitis control information and training. These practices include indicators and interactions with stakeholders (Table 3.7) and are used interchangeably to identify both needs and problems of regional stakeholders.

Table 3.7 Practices used by regional coordinators to diagnose stakeholders' needs and problems for mastitis control information and training.

Practices	Examples
Indicators	Bulk milk tank records CellCheck service provider database Discussion group membership
Interactions with stakeholders	Direct communication with farmers

Practice 1: Indicator tools

To diagnose the needs on mastitis control information and training, two indicators are used: bulk milk tank records and the CellCheck service provider database. The first indicator, bulk milk tank records, is used by the regional coordinators to investigate farmers' needs for mastitis control information. The CellCheck service provider database is used to diagnose the availability of trained service providers in region to form regional networks.

Bulk milk tank SCC records, are a resource regional coordinators are familiar with and have access as a dairy processor employee. Across all the case studies, it is the predominant metric used to identify and assess needs of regional farmers. Six out of the seven regional coordinators (RC1, RC2, RC3, RC5, RC6, and RC7) discuss using the test results to identify farmers is most need of mastitis control information within the region. Bulk milk tank tests are a herd level test, which is taken at dairy collection point by the tank driver. The test is undertaken on behalf of the milk collector (cooperative or dairy processor). The regional coordinators' use of bulk milk tank records to diagnose mastitis control information needs of farmers is supported by the findings in Kelly et al. (2009),

that low SCC levels are associated with good management practices and infrastructure for mastitis control.

Bulk milk tank SCC results are used by the regional coordinators, according to RC3, to '*identify problem farms*' and '*put them into groups of their own level on the cell count'*. It is deemed important to identify specific farm SCC levels to help group farmers that share similar mastitis information needs. RC3 explained the importance: '*it's a big difference from getting a man's cell count down that's over 300,000 say 400,000 to solve his problems as opposed to the man that's at 150,000 ... he's looking at all the little nitty gritty whereas the fella at 350,000 he has some major issue or issues on the farm that he has to change*'.

The regional coordinators define 'problem' cell count levels differently. This reflects the different standards set by regulatory law and dairy processors. The regulatory standard for milk supply within the European Union (EU) is 400,000 cells per m/litre. However, many dairy processors impose or are beginning to impose lower cell counts levels per m/litre of milk through incentive and penalty schemes. RC2 explains his employer's recent actions: '*we are reducing our cell count standards too from 400,000 down to 300,000*'. Processors are under pressure to set '*standards that our customers are looking for*'. Three of the respondents (RC1, RC2 and RC4) spoke about encountering large customers undertaking audits of processing plants and foresee a future where customers randomly select a farm to go and audit. RC4 explains: '*the day is coming when they will put a pin in a list and we will go out to a farm so we have to be conscious of that and try and make sure that farmers are producing or at least they are informed about how to go about best practice'*. Furthermore, with mounting pressure from the market RC5 refers to processors' actions on lowering cell count standards for milk supply as '*a marketing ploy to whoever's shouting the best results*'.

The second indicator, CellCheck service provider database is used by all seven regional coordinators, to investigate the composition of CellCheck trained service providers within their region. The database comprises of contact details for service provider personnel that have volunteered their services to the delivery of the CellCheck's regional activities. Use of the database enables the regional coordinator identify the distribution of service provider disciplines available including veterinary practitioners, milking machine technicians, Teagasc advisors and milk quality advisors. This helps inform the need for service providers to engage with CellCheck and participate in training. Table 3.8 gives examples of how the regional coordinators' use the information database for this purpose. At the time of interviewing, regional coordinators are using the information database to

facilitate the formation of multidisciplinary teams to deliver farmer workshops. Many of the regional coordinators are involved in developing the database by collecting contact details of potential volunteers at service provider training sessions.

Table 3.8 Examples from data of how the regional coordinators use the CellCheck information database to identify problems within their region.

Case	Quotes
RC7	'*we are scarce in vets and in milk machine technicians in certain areas*'
RC4	'*the uptake by volunteers is a bit uneven in that there are more volunteers in one area than in another*'…'*my area happens to be <specific county>, <specific county> and my nearest machine milking machine technician is located in <specific county>*' however '*there are a number of other milking machine technicians in the <specific dairy processor> area only they haven't volunteered yet*'

Practice 2: Interactions with stakeholders

The interviewees place importance on interactions with regional stakeholders to diagnose their problems. To deliver dairy processor duties, the regional coordinators regularly liaise and/or work with other stakeholders. In general, the regional coordinators come into contact with other service providers in the delivery of their processor duties. For example, RC1 discusses the importance of regular meetings with milk cooperative advisors to keep up to date on farmer issues and requests. RC1 says '*I would liaise with them, like we meet once a month and I could talk to them a couple of times within that month, so they are kinda my direct contact to the farmer if something is going on'* … in which '*CellCheck is would be included in that*'. Similarly RC3 values collaborative activities with farm advisory services to help deliver farm programmes. RC3 explains the relationship '*we worked together on a lot on things like this with the dairy farmers to bring them along*', and as such '*we don't see ourselves as separate as advisors*', and so '*if they've issues they contact us or if we with our suppliers and you know cause we're stretched like there's only two of us on the ground covering 800 suppliers*'.

In addition to interaction with service providers, regional coordinators communicate directly with farmers for problem identification. As dairy processor representatives, several of the regional coordinator has opportunities to meet with farmers. Phone calls,

farm visits, farmer feedback forms and other service providers are identified as ways in which regional coordinators learn about farmer needs and problems in relation to mastitis. For example, RC2 explains the importance of listening to farmer feedback

'*they will tell you coming from these workshops is that when they see the actual losses and if you took a cent a litre off their gallon or litre of milk they would go mad show them they could be losing four cent you know and these figures are there you know scientifically proved so that is one of the advantages of the workshop*'.

The regular interaction with farmers helps to identify the needs and willingness of farmers to engage in CellCheck activities. For example, at the time of interviewing, farmers' willingness to pay for farmer workshops was unknown. The general consensus among the regional coordinators was that farmers are unwilling to pay for farmer workshops. RC3 comments '*what I hear from my farmers is that it's hard enough to get them to come along but get them to come along and fork out for it'*. Furthermore, RC3 stresses that farmers in his region are reluctant to attend a workshop even if free.

3.6.2 Network Formation: Scan, Scope and Filter

To form regional networks, the regional coordinators' use a number of practices to scan, scope and filter service providers and farmers. For both stakeholders, membership of CellCheck regional networks and participation in CellCheck activities are voluntary. Network formation is important as it facilitates the operation of farmer workshops. CellCheck set out guidelines for selecting network participants. For farmer participants they suggest using farmer discussion groups and for service provider participants they suggest using the database on CellCheck trained service providers. The use of these resources avoids the need for regional coordinators to scan for appropriate service providers to deliver CellCheck activities such as farmer workshops. The network formation activities of the regional coordinators are not limited to this and some of the regional coordinators discuss forming regional networks with farmers experiencing problems with mastitis. The three practices used to form networks (Table 3.9) are discussed in this section.

Table 3.9 Practices used and the challenges they present on forming regional networks.

Practice	Method	Challenge
Narrowing the scope	SCC levels	Limited to processor milk suppliers
Filtering farmers	Contact Teagasc advisor	Non-discussion group members more likely to need mastitis control information
Scanning service providers	CellCheck information database	Lows levels of volunteers in service provider disciplines in some regions

Practice 1: Narrowing the Scope

Four of the regional coordinators (RC1, RC4, RC5 and RC6) select or plan to select farmers with problem SCC levels. RC5 explains the identification process '*computer system picking up suppliers and filter out those that are obviously in difficulty and then we will see the main offenders who need most* help' and *'take the people with the high count'.* Similarly, RC6 discusses selecting farmers with cell count levels between 200,000 and 400,000 per m/litre. There are limitations to regional coordinators using bulk milk tank records to select farmers. The records are confidential and the property of milk supplier's processor. As such, the regional coordinators have no access to the bulk milk

tank records of farms within their CellCheck region who supply to processors or cooperatives, of which they are not an employee. To address this issue, the regional coordinators suggest contacting neighbouring processors and cooperatives to inform and invite their suppliers to upcoming CellCheck workshops they intend to run.

Practice 2: Filtering Farmers

Three of the regional coordinators (RC2, RC4, and RC7) use the existing resources of Teagasc discussion group meeting to operate programme activities. As RC4 sums up '*I think the discussion group system is the ideal way*'. As previously mentioned, CellCheck encourage regional coordinators to use Teagasc discussion groups to source farmers for workshops but do not enforce it. Teagasc discussion group meetings are held on average once a month and are facilitated by a Teagasc farm advisor. Four out of the seven regional coordinators (RC1, RC2, RC6 and RC7), including those using this method to select farmers, state their scepticism with using discussion groups. RC1 explains that discussion group members have *'better technical knowledge and better milk quality in general*' and as such '*if they are in a discussion group they're not the group we are actually targeting*'. This is supported by positive associations within the Irish agricultural literature, between discussion group membership and technical performance in the Irish context (Bogue 2013; Hennessy 2012; Hennessy and Heanue 2012). For example, in a Teagasc survey undertaken in 2011, it was identified that 52% of discussion group members were achieving SCC levels under or equal to 200,000 m/l in comparison to just 23% of non-discussion group members (Bogue 2013). Furthermore, farmer feedback, collected by RC1, after a CellCheck workshop supports this association. RC1 selected farmers with high cell counts per m/litre of milk to attend the pilot workshop. The inability of the farmers to use a Californian Milk Test[29], a test for mastitis, and teat sealers, a preventative measure for mastitis, illustrates that they are non-discussion group members. RC1 explains

'this is where your difference in discussion groups and individual guys comes in where these guys some of them guys didn't know how to use California Milk Test and things like that and they were only learning on the day and they wrote that in their feedback they said "learnt how to use CMT" something else was teat sealer that they never knew you could use this as in a discussion group that is old news to them'.

[29] California Milk Test (CMT) also known as California Mastitis Test is a simple test for SCC in milk. It tests the level of infection of individual quarters. The test can be carried out by a farmer during milking. A four well plastic paddle is used, one well for each quarter. A small amount of milk from each quarter is put into a separate well on the paddle and equal reagent is then added to each. The solution is swirled and the gel reaction is given within 20 seconds. A positive result is when the solution starts to solidify.

Based on this, RC2, RC6 and RC7 state they will use discussion group meetings to run the pilot workshops but hope to select farmers for future workshops and the problem solving events based on farm SCC records to narrow the selection scope. RC7 explains his future approach to selecting farmers

'*working with suppliers who have problems with cell count because generally speaking eh the discussion group farmers eh the amount of them that may have problem cell count would be relatively small*'.

The regional coordinators are in agreement on the difficulties they face with encouraging non-discussion group members to attend farmer workshops. Based on experience working with this category of farmers, RC3 illustrates the challenge using a hypothetical scenario '*if you organise a meeting and had 16 or 18 at it 12 of them would be in discussion groups*'. Similarly, RC1 confirms the reluctance of this category of farmers to attend the recent CellCheck pilot farmer workshop '*so I think out of 24 people that we rang 13 of them actually went to the meeting*'.

Practice 3: Scanning Service Providers

All the regional coordinators use the CellCheck database to scan and select local service providers. During the service provider training seminars, contact details of attendees willing to volunteer services were collected and subsequently uploaded onto the information database by CellCheck. RC4 explains '*people who took part were put on the lists … and once they're on the list and to be honest any contact I've had with them they've been more than willing to participate*'. The regional coordinators directly contact the trained service providers to participate in CellCheck activities. RC1 explains the procedure to organise service providers for a recent workshop *'just called them up directly so when <CellCheck programme manager> sent out the information I had their emails'*.

A challenge to selecting service providers is the likelihood that they will be paid for their services. The conflict arises when farmers are unwilling to pay the workshop fee of €30 set out by AHI and the service providers, specifically self-employed veterinary practitioners and milking machine technicians, request payment for delivering a workshop. The other service providers employed by Teagasc, the dairy processors and certain veterinary practices are paid for their services by their associated organisations. This is due part of their commitment to financially support the programme. The regional coordinators are not concerned with resolving the issue, which is viewed unanimously as the responsibility AHI, but seek clarification on the matter for the purpose of workshop organisation. All seven regional coordinators confirm the unwillingness of industry

stakeholders such as AHI, dairy processors and milk cooperatives to pay for the services of service providers beyond their own personnel. For example, when organising farmer workshops, the regional coordinators receive payment queries from service providers. RC1 explains that when inviting service providers to partake in delivering a farmer workshop '*I suppose one of the questions that comes up is – "are we getting paid for this?". So money is always the issue somewhere along the way'*. RC2 and RC3 are unsure of AHI's decision to charge farmers to attend CellCheck meetings and believe it may hamper farmer incentive to attend. RC3 explains

'charging farmers it was one thing I felt they are in discussion groups now and they are getting paid on the DEP (Dairy Efficiency Programme) schemes you know paid to go to those meetings basically and here we are come along with other meetings that they don't want to go to they've realised the value of the problem we're going to charge them for it so I can see a bit of a challenge there'.

During the first interviews, there was widespread disparity among the regional coordinators on the collection and distribution of fees to service providers. All seven regional coordinators discuss the perceived reluctance and in some cases inability of farmers to pay for workshops, with the regional coordinators rationalising unwillingness based on the '*hard year'* in 2012 farmers experienced. However, RC7 identifies a group of farmers that should have no issue with paying an attendance fee. This group of farmers are members of dairy discussion groups as part of the Dairy Efficiency Programme[30]. RC7 explains '*discussion group farmers may not have an issue with paying for it*' as '*they're getting some funding from the EU'.* This is due to their participation in the Dairy Efficiency Programme.

In the events of the three workshops delivered by RC1, RC4 and RC7 no farmer paid an attendance fee. The regional coordinators argued it may be collected at a later date with two saying it could possibly be taken from milk cheques. Furthermore, the regional coordinators did not know if the service providers, involved in the delivery of the farmer workshop, invoiced AHI for their services. Within the six month period, this payment issue was resolved. AHI clarified payment collection. Farmers that attended workshops were obliged to pay a fee. This fee is collected by either invoicing the pre-nominated farmer (on the booking form) or directly deducting it from the farmer's milk cheque.

[30] Dairy Efficiency Programme (DEP) was run over the three year period 2010–2012. It was designed to promote dairy farmer participation in discussion groups. The aim was to improve management practices, efficiency and profitability on dairy farms. Programme participation was open to discussion group and non-discussion group members. Approximately €6 million was made available to eligible participants in each of 2010, 2011 and 2012. The programme promotes the adoption of best practice in grass management, breeding and financial management.

The information database is important because the regional coordinators do not have experience working with certain service provider disciplines. RC3 states unfamiliarity with veterinary practitioners, RC7 is unfamiliar with milking machine technicians within the region, and RC5 is unfamiliar with Teagasc personnel within the region. For example, RC5 says '*I wouldn't deal much with Teagasc people at all I wouldn't really know what their role is*'. However, gaps in service provider disciplines exist in the database. RC4 explains '*the uptake by volunteers for the system is a bit uneven in that there are more volunteers in one area than in another*'. The importance of a large database is noted particularly for large regions. RC4 explains

'*the obstacle is to get enough volunteers to volunteer their services, you don't want the people especially self-employed travelling over large distances maybe giving up half a day of the week to something that they may not see any monetary value for although their intentions might be good*'.

In addition to these three methods to select stakeholders, two of the regional coordinators (RC4, RC5) explicitly discuss considering the location of stakeholders when building regional networks. This location relates to the locality of their farm or practice. In both cases, the regions of RC4 and RC 5 are geographically large relative to the other regions. RC4 approach is to divide his region into '*localised kind of small areas maybe fifteen twenty mile radius regions within the area*'. Similarly, RC5 approach is to '*take the areas and then based on how many is in an area we'll have a couple of meetings with people that are over the 400,000'.*

3.6.3 Innovation Process Management: Enhance and Maintain

The practices used by the regional coordinators to promote and sustain stakeholder engagement with CellCheck, are best described as roles. These roles are undertaken to improve communication and learning between farmers, service providers, and AHI. To achieve this, the regional coordinators encourage best practice and learning and build trust (Table 3.10). These findings are discussed in detail in this section.

Table 3.10 Roles of regional coordinators to enhance and maintain the innovation process.

Role	Examples
Encourage best practice and learning	Milk recording Farm guidelines
Builder of trust	Build rapport with farmers and stakeholders

Role 1: Encourage Best Practice and Learning

The regional coordinators promote learning across regional stakeholders to maintain sources and uses of mastitis control within their region. This includes the promotion of CellCheck farm guidelines and CellCheck training. CellCheck's *Farm Guidelines for Mastitis Control*, was developed as a management and advisory tool for service providers and farmers and cost €15. '*Poor uptake on them'* has alerted regional coordinators to '*push them more*'.

The regional coordinators undertake a role to educate farmers on best practice for mastitis control. As RC3 states their role in includes reemphasising that to improve and maintain low cell count '*there's no quick fix and one thing we do at the meetings is tell them there's no magic potion. If somebody comes into your yard to sell a magic potion saying it's going to sort cell count its rubbish'*. One practice that all the regional coordinators promote is milking recording. Milk recording[31] is valued as best practice in keeping up to date on cow's mastitis health. Along with other industry stakeholders the regional

[31] Milk recording is seen as a valuable source of information on mastitis in a dairy herd. The Irish Cattle Breeding Federation (ICBF) coordinates the Irish milking recording service and there are two types of service: the Recorder service or the Electronic DIY (EDIY) service. A number of milk recording organisations operate in Ireland such as Progressive Genetics, Munster Cattle Breeding Group and Tipperary Co-op. Milking recording facilitates a review of individual cows in herd. Monthly milk recording is encouraged for mastitis control as it allows regular identification of problem cows, review of treatment, and monitoring spread of infection and stage of lactation. Furthermore milk recording allows review individual cows for yield of fat, protein and milk and identify infected cows early.

coordinators encourage farmers to enter milk recording schemes, although they are careful not to promote one particular scheme to maintain neutrality. RC4 explains the value of milk recording

'*people can get milk recording four six or eight times during the yea*r' …'*you can check and see which cows have high somatic cell count over a period and that way then if a cow has repeatedly high cell count even with treatment she has a real problem and she needs to be dealt with either by taking her out of the herd or maybe changing the medicine that is being prescribed for her*'.

RC2 and RC3 cite the inability of farmers to interpret results as a challenge to establishing milk recording practices. In 2012, milk recording was undertaken for approximately half a million cows representing 50% of the national herd (Irish Cattle Breeding Federation 2013). This was cited as a 2% increase on 2011 milk recording levels in Irish Cattle Breeding Federation (2013). Although approximately 50% of farmers engage in this practice, many are unable or unwilling to interpret results. These regional coordinators undertake an additional role of showing farmers how to interpret results.

In addition to the use of farm guidelines, the regional coordinators actively encourage service providers to engage in CellCheck training. At time of interviewing service provider training Stage 1 were completed nationwide and AHI were in the process of organising Stage 2 training. In some region, low numbers of veterinary practitioners and milking machine technicians' volunteers relative to other service providers have been identified. These disciplines are being targeted to partake in CellCheck training as service provider training and subsequently participation in programme through co-delivery of workshops is important to achieve CellCheck's goals. RC4 explains '*it's a big picture and the veterinary participation on mastitis or milk quality control is a relatively recent development that up to now they were they weren't that interested in the milk side of it'.*

Role 2: Builders of Trust

The regional coordinators work to deliver credibility in the CellCheck message on mastitis control to farmers. RC3 explains *'it's just to get the information out to the people and to give farmers the confidence that the information they're getting is independent'.* The regional coordinators are confident that CellCheck information on mastitis control works. RC2 sums up general opinion in his statement '*CellCheck does work*'. To encourage farmers to get involved in CellCheck, the regional coordinators emphasise the

importance of regular interactions to develop a good relationship with farmers. RC5 explains the importance of

'*having a good rapport with them*' when '*looking for them to do something different'* so too *'encourage them you know everybody's different, personalities are different but it's just something we're going to have to do'.*

Furthermore, good relations with local service providers are valued as important among the regional coordinators to the fulfilment of their role. RC5 and RC6 place importance on building a rapport with regional service providers. RC5 explains the importance of

'*getting to know the other personnel like the reps and the technical people*' as '*everybody's in the same boat we don't really know each other and just having an understanding of whose who really just to be able to build a database and use keep people in different areas cause we've a wide spread of area to cover*'.

3.7 Findings: Enabling and Constraining Arrangements

In this section, the findings on the arrangements that influence the practices and role chosen by the regional coordinators in CellCheck to fulfil their brokering role are identified and discussed. Four arrangements were identified that enable or constrain the execution of the brokering functions – demand articulation, network formation and innovation process management. They are conflict resolution, employer support, low levels of service provider engagement and the establishment of meetings. Each arrangement is explained in more detail below.

Conflict Resolution

As previously identified, a challenge experienced by the regional coordinators during network formation was the unwillingness of farmers to pay to attend farmer workshops and the expectation of service providers to receive payment to deliver the workshops. During the six month period in interviewing, AHI addressed this situation and clarified that farmers were obliged to pay to attend workshops which would be used to pay the service providers for their services. RC1 explains that AHI resolved the payment issued through '*coordinated administration*' of farmer payments. In agreement with farmers, processors put in place a system to deduct payment from a farmer's milk cheque and transfer payment directly to AHI. The second round of interviews revealed that the regional coordinators are satisfied with the new agreement. The resolution of this conflict helped to clarify among the regional coordinators their role and responsibilities in the collection and distribution of fees. RC2 stated that now that AHI had put an administration system in place the sole role of the regional coordinators relating to workshops payments was '*to implement it now'*.

Employer Support

Support from their affiliated dairy processor enables the regional coordinators to fulfil their role. For example, support through a reduction in work duties allows the regional coordinators' time to fulfil their CellCheck role. RC1, RC3 and RC4 discuss their processor duties as constraining the time available to organise CellCheck workshops. RC4 is disappointed with the low number of farm workshops he delivered over the six month interview period. RC4 tributes the poor performance on time constraints and pressure placed on him to complete processor duties before CellCheck. RC4 explained that the view of his processor employer is that the regional coordinator role is '*is only part of the job*'. RC4 clarifies that there is '*no resistance'* by the dairy processor to '*spending more time*' on the CellCheck role but the dairy processor '*does not encourage this'*. On the contrary, RC2 and in particular RC7 credits his associated dairy processor as '*very supportive'* of the CellCheck role. The processor allowed the distribution of farm

guideline books to all suppliers, and the fee to be deducted from milk cheques, to promote suppliers' engagement with the CellCheck programme. There is no data available to inform the impact of the innovation brokering role on improving interactions within CellCheck. This finding endorses the argument in Klerkx and Leeuwis (2008a) and Klerkx and Leeuwis (2009a) for public funding agencies to support innovation brokering, as its impact can be difficult to measure thus, making it difficult to place a monetary value on it.

Low Levels of Engagement

Another challenge identified in the data to successful network formation was the low levels of service provider engagement in certain regions. This affects the ability of the regional coordinators to form regional networks as they are restricted to selecting service providers that have completed Stage 2 training. AHI are responsible for maintaining and updating the service provider information database with contact details of providers that volunteer services. An unsuccessful effort to improve the number of service providers volunteering their services to CellCheck is identified as constraining the ability of the regional coordinators to execute network formation.

During the six month period between interviews, AHI implemented a communication strategy to improve the number of service providers volunteering their services to CellCheck. This involved invited writing to service providers to invite them to attend upcoming CellCheck training seminars. However, the efforts were not effective. For example, RC1 comments that the most recent list of service provider volunteers received from AHI is '*not great*' and '*feels a bit restricted*'. More specifically, the type of service providers that have engaged with CellCheck differs across the regions. RC6 adds that there are '*plenty*' of Teagasc advisors and milking machine technicians available to present farmer workshops with just about '*enough vets but would like more*'. RC6 discusses the overall '*poor response*' of veterinary practitioners in region in Stage 2 training '*relative to the number of vet practices in the area*' suggesting the communication activities of AHI involving an '*invite in the post*' may not be sufficient. RC2 and RC4 cite low levels of participation among milking machine technicians within their regions. RC2 says that a small number of technicians participated in level two training relative to the number registered with the Irish Milk Quality Co-operative Society[32] (IMQCS). RC4 addresses the low number of milking machine technicians in the

[32] The objective of the organisation is to improve milk quality standards in Ireland by ensuring milking machine installation and testing standards equate with international standards. The organisation maintains a list of milking machine technicians that have undergone approved training and certification. There are currently 195 technicians registered with IMQCS for 2013.

region by '*tapping*' into those located in neighbouring region. RC2 says that milking machine technicians are '*hard to get*' as those that RC2 asked replied '*they are not interested*'. RC6 and RC2 are sceptical of AHI approach to engage with service providers. RC2 emphasises the need for a more direct form of communication as '*people don't read things that come in the post like that*'.

Establishment of Meetings

In the six month period between interviews, AHI scheduled meetings for the regional coordinators to meet with each other and exchange experiences to gain insight into the practices used by the other regional coordinators to fulfil their role. All the regional coordinators agreed that these meetings provided an opportunity to learn from each other. In particular, RC1 and RC4 attribute changing their practices of network formation after learning about the practices of RC6 at a regional coordinator meeting. Both RC1 and RC4 reference the achievement of RC6 in organising and delivering 18 farmer workshops (within the six month time period). RC6 achieved this number of workshops by writing to milk suppliers with SCC over 100,000 per millilitre. In each letter, the financial losses occurred by the milk support due to the incidences of SCC levels are calculated using the CellCheck CostCheck[33]. RC4 cited that RC6 received a '*10% response rate*' overall. The milk suppliers that responded were subsequently invited to attend a workshop within their vicinity. Two days in advance of the event, RC6 followed up with farmers, via phone call, to confirm their attendance. In addition, the meetings provide a forum for the regional coordinators to get know each other and RC4 and RC7 anticipate that opportunities could arise from attending these meetings to observe workshops organised by other regional coordinators.

[33] The Cost Check calculator is a Microsoft Excel based tool that estimates the potential gains in farm profit arising from a reduction in the incidence of mastitis on a dairy farm, using farm specific information. The tool was developed by Teagasc Moorepark Research Centre in consultation with the CellCheck Technical Working Group.

3.8 Discussion: Supporting a Part Time Innovation Broker

Overall, the organisational arrangement CellCheck signifies neither a bottom up nor a top down approach to resolving the problem of mastitis in the Irish national dairy herd but an experimental network as discussed in the work of Sabel and Zeitlin (2012; 2008). CellCheck came about when Irish dairy stakeholders (public and private) shared uncertainty on how to resolve the mastitis control problem agreed and recognising their individual limitations to resolving the mastitis control problem agreed to work in partnership to collectively address the issue. This establishment of an innovation brokerage function within CellCheck signifies that although the stakeholders agreed on the need for collective action for problem solving, a facilitator is needed to prevent system failure through builsing and maintaining interactions between actors within the problem focused innovation system.

The study focused on the identified part time innovation brokers established to assist knowledge exchange among the dairy stakeholders within the seven regional networks in CellCheck. Using the innovation broker literature, the activities of the seven part time innovation brokers referred to as regional coordinators were explored. The documented practices and roles undertaken by the regional coordinators to fulfil the functions of demand articulation, network formation and innovation process management were identified and examined to provide an explanation of how part time innovation brokers execute their role. In summary, the findings detailed in section 3.6 and section 3.7 show that a combination of practices, influenced by a number of environmental arrangements, are chosen by the regional. In this section, the case study findings are discussed. More specifically, five emerging themes relating to the practices selected are identified and discussed. They include experimenting, context analysis, historical experience, organisational connection, and programme guidelines. In this section, the five themes are discussed. Next, the case study findings are reviewed to help develop propositions to guide AHI in supporting the part time innovation brokers in CellCheck.

3.8.1 Part Time Innovation Brokering: Practices and Themes

To begin, the findings confirm that the brokering function in CellCheck emerged purposefully and not serendipitously as differentiated in Klerkx, Hall and Leeuwis (2009). In addition, the brokering role is evolving, as previously discussed in Anandajayasekeram and Gebremedhin (2009) and Klerkx and Leeuwis (2008b). During the six month period of analysis, changes occurred in the practices and roles of the regional coordinators. These changes are a function of the individual learning of the regional coordinator which confirms the evolving nature of network activities as actor

learning occurs, previously discussed in Sabel and Simon (2012). Although the findings cannot confirm that changes within the innovation system (CellCheck), influenced changes in the practices and/or roles undertaken by the regional coordinators' previously argued in Batterink et al. (2010); Klerkx, Hall and Leeuwis (2009) and Klerkx and Leeuwis (2009a), the case study findings confirm that the seven brokers are aware and accepting of their need to change their practices to fulfil their CellCheck role as the programme evolves over time.

It is evident that the practices used by the regional coordinators facilitate the interpretative component of innovation discussed in Lester and Piore (2004). The role of the innovation brokers in CellCheck can be viewed as that of the interpretative manager in the process of new product development. The interactive process between the farm stakeholders is continuously evolving. The role of regional coordinator, like that of the interpretative manager, is to remove barriers between the diverse stakeholders to facilitate these conversations as it is assumed that the ambiguity in the conversations is where the new ideas emerge. The objective of the regional coordinator is to identify new meaning by encouraging conversations between them at events, such as service provider training seminars and farmer workshops, to explore the ambiguity. The conversations are fluid, context dependent and undetermined like those characterised by Lester and Piore (2004) in the interpretative process. In the case of CellCheck, it is evident that the stakeholders cannot articulate their requirements for mastitis control information but, through continuous engagement in these conversations, some facilitated by the regional coordinators, their needs emerge. These are identified by the regional coordinators and are used to inform their practices and the future activities of CellCheck.

The innovation brokering process, concerned with dismantling boundaries between the different actor groups, can also be understood as a combination of analytical and interpretative approaches, discussed in Lester and Piore (2004). For example, in the process to articulate the problems and needs of the stakeholders, the SCC benchmark set by the individual processors and the means of the regional coordinators to measuring it, such as SCC farm indicators, can be understood analytically. In addition, the identified social interactions with regional farmers and service providers can be thought as ways to stimulate and direct conversations on mastitis control. The identified practices and roles that represent analytical interactions are listed in Table 3.11. Those that represent the interpretative interactions are listed in Table 3.12.

Table 3.11: The practices and roles of the regional coordinators to facilitate the analytical process.

Regional Coordinator Activity	Practice or Role Used	Examples
Demand articulation	Indicators	Bulk milk tank records
		CellCheck service provider database
		Discussion group membership
Network formation	Narrowing the scope	SCC records
Innovation process management	Encourage best practice and learning	Milk recording
		Farm guidelines

Table 3.12: The practices and roles of regional coordinators to facilitate the interpretative process.

Regional Coordinator Activity	Practice or Role Used	Examples
Demand articulation	Interactions with stakeholders	Direct communication with farmers and service providers
Network formation	Filtering the farmers	Contact Teagasc advisor
	Scanning service providers	CellCheck information database
Innovation process management	Builder of trust	Build rapport with farmers and service providers

From the case study findings, five themes emerged that represent the activities of the regional coordinators to fulfil their innovation brokering role relating to demand articulation, network formation and innovation process management. These include experimental, context analysis, historical experience, organisational connection, and programme guidelines. These themes are discussed in further detail below.

Theme 1: Experimental

Operating in the context of an experimental network which evolves over time as actor learning occurs (Sabel and Simon 2012), it is evident from the case study findings, that although broad guidelines are set out for the regional coordinators on how to fulfil their role, they share uncertainty about the necessary practices and roles. As such, they apply a '*trial and error*' approach. The regional coordinators do not confine themselves to the options predefined by AHI, those available to them through their associated dairy

processor, or their previous experience. This finding is confirmatory with the innovation brokering literature which emphasises the belief that '*practice makes perfect*' through the process of '*learning while trying'* (Klerkx and Gildemacher 2012; Sabel and Simon 2012). Learning is influenced by context analysis, the second theme identified in the case study findings and discussed next.

Theme 2: Context Analysis

The practices undertaken by the regional coordinators reflect the specific characteristics of the regional network it operates in. Klerkx and Gildemacher (2012) and Klerkx, Hall and Leeuwis (2009) advocate context analysis prior to establishing an innovation broker. However, the case study evidence shows the regional coordinators undertake context analysis on an on-going basis which influences the practices chosen by the individuals. They are highly dependent on their unique interpretation of the needs of the stakeholders within their specific region. This is in agreement with the understanding in the literature that the practices used are a function of a broker's understanding and judgement of the phase of development, composition and strength of interactions of the innovation system within which it is embedded (Madzudzo 2011; Winch and Courtney 2007; World Bank 2006).

The findings in this study show that the identified needs of regional stakeholders inform the regional coordinators of what is necessary and possible to fulfil their functions. For example, the willingness of service providers and farmers to engage with CellCheck differs across the regions. As such, several of the regional coordinators are required to focus efforts on promoting CellCheck among service providers and farmers to encourage participation prior to the commencement of activities to form networks. Therefore, the significance of this difference between the literature and the case study findings is that context analysis is not a once off activity delivered in a top down approach but an on-going process undertaken by the innovation broker. Once again, this reflects the evolving nature of activities within the experimental network approach to problem solving.

Theme 3: Historical Experience

Purposefully selected from the dairy processing sector, the regional coordinators apply their experience working within the sector and with other dairy stakeholders when fulfilling their part time role in CellCheck. Their prior experience includes the organisation and management of farm level programmes, addressing specific farm cases of mastitis, and interacting with farmers and dairy service providers to fulfil daily processor duties. Most notably, their experience working in the dairy industry enables the regional coordinators to determine a farmer's need for mastitis control information based

on whether they are members of farmer discussion groups. In addition, their experience in organising farm level programmes similar to CellCheck which focus on reducing somatic cell counts attributes to their confidence in their in their ability to fulfil their role in CellCheck.

Contrary to the suggestions in the innovation brokering literature that existing organisations within the sector may find it difficult to undertake a brokerage role (Klerkx and Gildemacher 2012; Devaux et al. 2009; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a), the findings in this study show the beneficial role of selecting individuals with prior experience and thus the social connections and confidence to fulfil a brokering role within the dairy sector. In addition, the findings show that there is no need to choose personnel who are detached from the existing actor groups to establish credibility and enable the innovation brokers to act freely to fulfil their role as suggested in Klerkx et al. 2012, Klerkx, Hall and Leeuwis 2009 and Klerkx and Leeuwis 2008a. The case study findings are confirmatory with the work of Burt (2004) on choosing personnel to bridge structural holes that possess social networks across the structural holes as they are familiar with the alternative ways of thinking and behaving that exist across the actor groups.

Theme 4: Organisational Connection with Dairy Processor

Complementary to their use of historical experience working within the dairy processing sector, the regional coordinators draw on their organisational connection with their affiliated dairy processor to help fulfil their part time brokering role in CellCheck. All seven regional coordinators use tools available to them through their organisational connection with the dairy processor. These tools include bulk milk tank tests and existing organisational linkages with other dairy stakeholders such as Teagasc. This finding once again highlights the weakness in the innovation brokering framework on the assumption that existing organisations within a sector face difficulty with fulfilling a brokerage role (Klerkx and Gildemacher 2012; Devaux et al. 2009; Klerkx, Hall and Leeuwis 2009; Klerkx and Leeuwis 2009a). In fact, the results from this study confirm the findings in Burt (2004) that choosing organisations or personnel who already work within a sector to undertake a brokering role provides access to existing social networks which span across structural holes assists an innovation broker in the fulfilment of its functions.

Theme 5: Programme Guidelines

The regional coordinators use the predefined practices, outlined by AHI, to carry out activities they are unfamiliar with. For example, to scan service providers to form regional networks, AHI suggest using the CellCheck information database to source

service providers. The case study findings reveal that the database is used by all the regional coordinators to find contact details for other service providers within their region who they do not know and/or have not worked with before. This finding suggests that although the fulfilment of the role relies on '*learning while trying*' and '*trial and error approach*' i.e. experimentation, as discussed in Klerkx and Gildemacher 2012; Klerkx and Leeuwis 2008b, standardised practices are required to guide the regional coordinators in CellCheck on the fulfilment of activities which they are uncertain of or inexperienced with. The lack of understanding on the requirement of standardised practices for newly established brokers, beyond the three generic functions, in the innovation brokering literature suggests a weakness in the framework.

3.8.2 Propositions for Supporting Part Time Innovation Brokers

Based on the case study findings, four propositions on supporting the part time innovation brokers in CellCheck are derived. They are the promotion of experimentation and the synergy of practices to fulfil the innovation brokerage role; prior analysis of the context in which the innovation brokerage function is to be embedded; the development of templates for activities outside the remit of the broker's core occupational role; and lastly, the establishment of a peer networking group. Each proposition is discussed in more detail below.

Proposition 1: Promote Synergies between Full time and Innovation Brokerage Roles

The first suggestion proposed is for AHI to promote synergies between the full time occupational role in the dairy processor and the part time innovation brokering role in CellCheck. It is evident from the case study findings that the mixed identities associated with the part time innovation brokerage role in CellCheck and the full time occupational role in the dairy processing sector can have a positive effect on the execution of the brokering functions.

The findings show that the practices of the regional coordinators are influenced by their core occupational role within the dairy processor. For example, all seven use bulk milk tank test results carried out by the processor organisation to understand the mastitis control information needs of farmers within their region. This implies that although the part time innovation brokers face an additional responsibility of managing their mixed identities in an effort to maintain neutrality and credibility, as suggested in Klerkx, Hall and Leeuwis (2009), it is evident from the empirical analysis in this study that the organisational connections of brokers are beneficial to the fulfilment of the part time

innovation brokering role in CellCheck.This implies that it may be useful for AHI to review the core occupational role of the regional coordinators to identify beneficial synergies between that and the innovation brokering role.

As although they are positioned in the problem focused innovation system as organisationally detached from their core occupational role and the associated organisation, connections with their core occupational organisations helps in the fulfilment of a brokerage role. To prevent tension, the literature emphasises setting out a distinct and limited mandate for the innovation broker. An area of further work is to assess the impact of this organisational connection on the neutrality of the innovation broker.

Proposition 2: Prior Analysis of Context and Full Time Role

The second suggestion proposed is that the AHI, the organisation responsible for establishing the innovation brokers, undertakes prior analysis of the context within which the brokers are to be embedded and the full time occupational role of the brokers. The case study findings confirm the argument in Klerkx and Gildemacher (2012) for diagnosing the strengths and weaknesses within the innovation system prior to embedding an innovation broker. This is based on conviction that each innovation system is context specific and thus the activities of the innovation brokers differ across innovation systems. In this study, such differences presented conflict on the achievements across the group of innovation brokers. The identification of environmental arrangements which are causing such conflicts can be used to inform appropriate action to address these issues and promote coherency in the achievements of the individual innovation brokers.

The case study findings also imply the need to undertake prior analysis of the core occupational role of the part time innovation broker to identify gaps between this role and that of innovation brokering. These gaps can relate to time, resources or experience to fulfil certain innovation brokerage functions. In this study, the negotiation of time between full time role and part time innovation brokerage role was a problem experienced regional coordinators.

It is also evident from the findings that the innovation brokers in CellCheck engage in continuously diagnosing the innovation system within which they are embedded. For example, they identify missing actors in terms of farmer groups and service provider disciplines which hinder network formation, as well as weak levels of interaction between actors such as service providers and AHI.

Proposition 3: Develop Templates for New Activities

The third suggestion proposed is that AHI develop templates for new brokering activities that extend beyond the experience of the regional coordinators, identified through prior analysis of the occupational role. For example, the case study findings suggest the usefulness of developing a template on how regional coordinators might engage with other service provider disciplines, particularly those with which they are unfamiliar.

Furthermore, the findings suggest that the development of standardised templates might avoid discrepancies between the goals and achievements of the innovation brokers. For example, the activities of several of the regional coordinators in CellCheck indicate a focus on problem solving cases of mastitis (based on identification of problem farms using bulk milk tank test results) whereas the objective of the CellCheck programme is to increase stakeholder understanding of mastitis control to improve national milk quality.

Proposition 4: Establish a Peer Networking Group

The fourth suggestion proposed to help AHI support the innovation brokers is to establish a peer networking group. The case study findings confirm the importance Klerkx and Gildemacher (2012) place on peer to peer exchange relating to experiences, successes and failures with a new innovation brokerage role. The findings from the empirical analysis show the positive influence regional coordinator meetings have on the practices and the further evolution in the practices of the regional coordinators. The meetings provide a platform for the individuals undertaking the role to exchange experiences and learn of the success and failures of peers.

For part time innovations brokers setting a time and place to exchange and reflect on their experience within innovation brokering is particularly important as they negotiate their time between innovation brokering and their core occupational role. Although the innovation systems in which innovation brokers operate are unique, the experiences of the innovation brokers can serve to guide and inspire others as they face similar problems and challenges.

These measures can be implemented by the actor (in this case AHI), or group of actors, who purposefully establish the innovation brokerage function. The measures can be differentiated as rigid or flexible. Rigid measures relates to those that can be set in place prior to establishing the innovation brokerage function and include prior context analysis of the innovation system, development of templates and the establishment of a peer networking group. The only flexible measure, the promotion of synergies between the

roles, requires continuous implementation and evolves to accommodate changes that occur within the contextual environment.

3.8.3 Contributions

There are a number of contributions that arise from this study; they are as follows. First, the study contributes four recommendations, characterised above as either rigid or flexible, for supporting the establishment of part time innovation brokers. They include the promotion of experimentation and a synergy of practices between the core occupational role and innovation brokerage role; prior analysis of the context in which the innovation brokerage function is to be embedded; the development of templates for activities outside the remit of the core occupational role; and lastly, the establishment of a peer networking group.

Second, the study contributes new empirical evidence to the theory of innovation brokering on the activities associated with innovation brokering.. The study identifies five characteristics of the process of part time innovation brokering. They are experimentation; context analysis of the innovation system in which it is embedded; historical experience; innovation brokering guidelines and organisational connections associated with the core occupational role. These findings provide insight into how agricultural part time innovation brokers operate and in which conditions they function most effectively, to help address the question posed in Winch and Courtney (2007).

Third, the study provides new theoretical insights to the process of innovation brokering. The study identifies that the innovation brokers engage in interactive processes during the fulfilment of their functions. Using the work of Lester and Piore (2004), the types of interactive processes can be characterised as analytical or interpretative in nature. This framework presented in Lester and Piore (2004) provides a deeper understanding of the types of interactions that the brokers engage in. In addition, this framework can provide a better explanation of the different types of connections, which are context dependent that the brokers must build between network actors.

Fourth, the findings confirm the establishment of a part time innovation brokerage function as an alternative and broader conceptual framework to information brokering across structural holes, discussed in Burt (2008a; 2008b; 2007; 2004) and Lomas (2007). Following the problem focused innovation system approach, developed in Metcalfe and Ramlogan (2008), the identified innovation brokers in CellCheck are sourced from the *'innovation ecology*' of the Irish dairy industry. The findings on the brokers' activities

confirm that they adhere to operating as independent, third party actors within their regional networks and to bridge the structural holes and facilitate knowledge exchange.

Fifth, following on from the previous contribution, the case study of CellCheck provides new empirical evidence to the theory of a problem focused innovation system. The case confirms the experimental nature of the organisational regime and thus, contributes to the process conceptualisation of an innovation system. Furthermore, these findings confirm this type of innovation system as an organisational arrangement that used as a policy making tool to resolve uncertain system problems, as discussed in the work of Sabel and Zeitlin (2012; 2008).

Sixth, this study extends the entities that can undertake an innovation brokerage role to include a network of individuals from different organisations. The study found that this form of innovation brokerage function can adhere to the core value of credibility emphasised in Klerkx et al. (2012), Klerkx, Hall and Leeuwis (2009) and Klerkx and Leeuwis (2008a). This is achieved by addressing the neutrality, functional ambiguity and funding tensions.

3.8.4 Future Work

In this section, a number of areas for future work are proposed. The first area proposed is an examination of the perceptions of Irish dairy farmers towards the innovation brokering role within CellCheck. In particular, the focus would be on whether the role and the activities of the identified innovation broker are perceived as independent from their affiliated processor. This would usefully consider the impact of part time innovation broker activities on the important values of neutrality and credibility.

A second area for future work could be a comparative analysis of the activities of full time and part time innovation brokers, operating within a similar context, in order to identify the specific operational challenges and opportunities that they each face. These may relate to credibility, mixed identities, and funding.

A third area for future work could be an exploration of how innovation emerges through an ethnographic study of innovation broker activities which aim to coordinate innovation over time. The activities of the regional coordinators in CellCheck to organise stakeholder interactions could be tracked in order to understand further, and in greater detail than this study allowed, the ways in which innovation emerges and develops in practice. Hoholm and Araujo (2011) argue that by examining the process in '*real time*' to further improve

understanding of the how innovation unfolds in practice. This study on innovation brokering was constrained to leaving a maximum of six months between the interviews due to the time constraints of the PhD project.

A further topic would be an examination of the impact of the innovation brokering network on the diffusion of mastitis control practices in Ireland. The diffusion of mastitis control practices can be identified from farm SCC levels. These are currently being compiled by the Irish Cattle Breeding Federation (ICBF) for future publication.

3.9 Conclusion

This study addresses the problem of coordinating interactions in a network to facilitate knowledge exchange for innovation. The establishment of an innovation brokerage function is one approach to coordinating actor interactions for innovation. By examining the activities of seven identified part time innovation brokers in the national mastitis control programme, CellCheck, this study contributes to the literature on innovation brokers the actual practices and enabling environmental factors that influence the activities undertaken by a part time innovation broker.

The findings confirm that innovation brokering is a process of experimentation, context analysis, historical experience, organisational connections, and following programme guidelines. Based on the experimental nature of the role, the activities of part time innovation broker continuously evolve to adapt to changes that occurring within the innovation system. In this study, such changes relate to clarification in the administration of farmer workshop payments, employer support, service provider engagement in the programme and the establishment of meetings. Based on these findings, four propositions for supporting the establishment of a part time innovation brokering function were developed. The results indicate innovation brokering undertaken on a part time basis could benefit from the promotion of synergy between the core occupational and innovation brokerage roles, the prior analysis of the innovation system in which they are being embedded and the workload of the full time role, the development of templates to guide the organisation of unfamiliar activities and the establishment of a peer networking group.

4 A Policy Approach to System Innovation: Systemic Instruments in the Irish Agri-Food Industry

4.1 Introduction

The innovation system is the environment within which innovation takes place. If problems occur within the system, network or interactive processes within an innovation system this hinders the overall performance of the innovation system. Systemic instruments are an integrated approach to addressing system problems as opposed to problems at the level of the firm. Policy tools are used to implement the goals of systemic instruments.

Two policy objectives of Irish agri-food are sustainable food production and the development of functional foods (Research Prioritisation Project Steering Group 2012). The focus of this research study is on the implementation of the systemic instruments namely Origin Green and Food for Health Ireland which aid the achievement of these objectives. Using a case study approach, the study seeks to explore the systemic policy framework developed Wieczorek and Hekkert (2012), as a guide for policy makers in the design and implementation of systemic instruments. The framework has not been tested in such a way to date. The study builds on existing theory and more specifically the guidelines for implementing systemic instrument goals. The systemic policy framework is one approach to using the innovation systems concept as an operational tool, which is an under researched area within the field of innovation systems (for an exception, see World Bank (2006)).

The study is structured as follows. In the next section, the conceptual framework is discussed. The section begins by defining the key concepts used in this study namely systemic policy, systemic problems and systemic instruments and their goals. Next, the systemic policy framework applied in this study is outlined. Section 4.3 outlines the research question. The case studies selected and the empirical context of the Irish agri-

food industry is detailed in section 4.4. Section 4.5 contains the findings. 4.5. Section 4.6 contains the discussion and the conclusion is in the final section, 4.7.

4.2 Conceptual framework

The aim of a systemic policy is to influence system wide change (Edquist 2011). Systemic policy is designed at system level and involves all actors within an innovation system (Edquist 2011; Klein Woolthuis, Lankhuizen and Gilsing 2005). The elimination of problems in an innovation system can give rise to system wide change; in other words, system innovation (Van Mierlo et al. 2010). Systemic instruments are purposefully employed to address these problems by improving weak or missing elements within the innovation system. The design of systemic instruments to implement system innovation is the focus of this study. In this section, the main concepts used in this study are explained.

4.2.1 Systemic Instruments

The literature distinguishes systemic instruments from traditional policy instruments such as financial and diffusion instruments. The distinction is based on the former's specific formulation to address a problem in an innovation system (Wieczorek and Hekkert 2012; Klein Woolthuis, Lankhuizen and Gilsing 2005; Smits and Kuhlmann 2004). Wieczorek, Hekkert and Smits (2011, p16) define systemic instruments as

'*methods and mechanisms used by governments, political parties, businesses and individuals to organise, coordinate and direct innovation systems*'.

The rationale for developing such instruments is that action to address innovation system problems requires instruments that do not solely support individual organisations (e.g. financial instruments) or relations between organisations (e.g., diffusion instruments) but instruments that support system wide change (Smits and Kuhlmann 2004). Two examples of systemic instruments established in the Netherlands are as follows. First, the E-Commerce Platform Nederland project (1994-2002) developed new ICT institutions on the exchange of information (Klein Woolthuis, Lankhuizen and Gilsing 2005). Second, the Dutch Initiative for Sustainable Development (1999-2004) used a collection of projects to enhance the Dutch knowledge infrastructure on sustainable development (Van Mierlo et al. 2010). Systemic instruments are an alternative form of a problem solving arrangement implemented at system level used in policy making to that of experimental networks identified in Sabel and Zeitlin (2012; 2008). Both forms of organisation emerge to address problems that cannot be solved by established knowledge and the uncertainty overcomes hierarchical governance and 'command-and-control' regulations in the setting (Sabel and Zeitlin 2012; 2008). The problem solving activities are multi-level involving system, network and interactive process, which involve joint exploration and learning accessed through interactions.

4.2.2 Operation of Systemic Instruments

Smits and Kuhlmann (2004) emphasise that systemic instruments operate at system level. These instruments address problems in an innovation system in an integrated way by putting one or more of the following five conditions into action:

- Managing interfaces (between actors)
- Building and organising innovation systems
- Providing a platform for learning (for all actors)
- Providing a structure for strategic intelligence and demand articulation
- Developing a strategy and vision.

Other studies on systemic instruments (Wieczorek and Hekkert 2012; Wieczorek, Hekkert and Smits 2011) have extended the list of conditions to include the following:

- Stimulate and organise participation of actors
- Create space for actors' capability development
- Stimulate occurrence of interactions
- Prevent too strong and too weak ties
- Secure presence of (hard and soft) institutions
- Prevent too strong and too weak/ stringent institutions
- Stimulate physical, financial and knowledge infrastructure
- Ensure adequate quality of infrastructure.

To put a condition into action (i.e. to operationalise a condition), in an integrated way, requires a combination of policy tools (Wieczorek and Hekkert 2012; Wieczorek, Hekkert and Smits 2011). The tools chosen depend on the nature of the problem identified, interactions with other tools and the contextual nature of the environment in which it is embedded (e.g. policies and infrastructure) (Wieczorek and Hekkert 2012).

4.2.3 Identifying Problems in an Innovation System

There are two schemes of analysis for assessing system performance and identifying factors that influence performance of an innovation system (Lamprinopoulou et al. 2014; Bergek et al. 2008). The first approach focuses on the 'components' within the innovation system referred to in this study as the structural elements namely actors, interactions, institutions and infrastructure. This scheme is referred to as *structural innovation system analysis* (Lamprinopoulou et al. 2014). The second approach focuses on the 'activities' within the innovation system known as the functions (Edquist 2011). This scheme is referred to as *functional innovation system analysis* (Lamprinopoulou et al. 2014; Bergek et al. 2008; Hekkert et al. 2007). The innovation systems literature is generally in agreement on the list of functions required in an innovation system although phrasing used by scholars can differ. The functions are as follows:

- Entrepreneurial activities
- Knowledge development
- Knowledge diffusion
- Guidance of search
- Market formation
- Mobilisation of resources
- Creation of legitimacy.

(Bergek et al. 2008; Hekkert et al. 2007)

Traditional innovation system analysis focused on weaknesses in the structural composition of the innovation system using structural analysis. This signifies the interpretation of an innovation system as a support infrastructure, the principal view in the innovation systems literature (Klerkx, Van Mierlo and Leeuwis 2012; Bergek et al. 2008). However, most recently, the literature has diverted its attention to the functions within the system (Edquist 2011) as it is deemed inefficent to evaluate good versus bad structural elements without examining their effect on the innovation processes and subprocesses i.e. functions (Bergek et al. 2008; Hekkert et al. 2007). Individually and collectively the functions support innovation and the performance of each function is dependent on the development and activities of the other functions (Hekkert et al. 2007). This study undertakes a functional perspective of the Irish agri-food innovation system. With the exception of Lamprinopoulou et al. 2014, a functional perspective has mostly been applied to technological innovation systems (Klerkx, Van Mierlo and Leeuwis 2012; Bergek et al. 2008; Hekkert et al. 2007). From this perspective, it is assumed that functions that are weak or missing negetively influence the path and speed of innovation which in turn hinder the development and overall functioning of the Irish agri-food innovation system as a whole (Wieczorek and Hekkert 2012; Bergek et al. 2008; Johnson

2001). Thus, in this study weak or missing functions are viewed as problems in the innovation system also referred to here as systemic problems[34].

Systemic instruments are interventions to address systemic problems to achieve systemic policy goals. The recent development of the systemic policy literature and the associated analytical frameworks enable researchers or policy makers to identify systemic problems and design systemic instruments to implement action to achieve policy objectives. It is for this reason the concepts related to systemic policy such as systemic instruments, systemic problems and policy tools, form the basis of this study. The concepts are defined and the relationships between them outlined in Table 4.1 and Figure 4.1 respectively.

Table 4.1 Definitions of main concepts used in this study.

Concepts	Definition
Systemic Policy	Action by public organisations to influence system wide change
Systemic Problem	A weak or missing element in an innovation system
Systemic Instrument	Methods and mechanisms used by governments, political parties, businesses and individuals to organise, coordinate and direct innovation systems
Set of policy tools	Activities that operationalise the conditions needed to address problems in innovation systems

[34] Other studies use the terms system failures, system weaknesses or system imperfections (Wieczorek and Hekkert 2012; Bergek et al. 2008; Klein Woolthuis, Lankhuizen and Gilsing 2005).

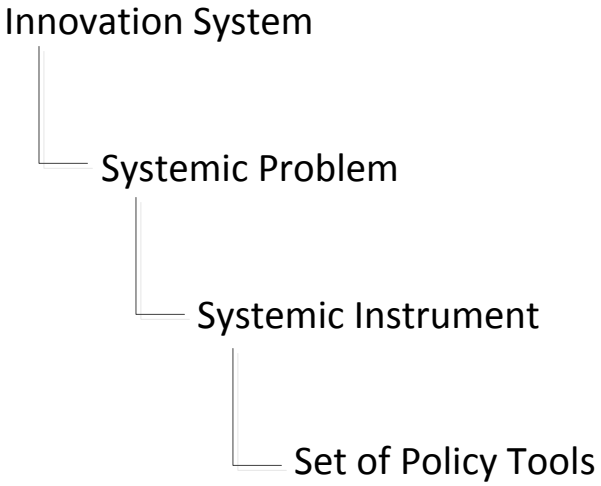

Figure 4.1 Relationship between innovation system, systemic problem, systemic instrument and policy tools.

4.2.4 Frameworks to Design Systemic Instruments

In the systemic instrument literature, two frameworks are set out to guide policy makers in the formulation of systemic instruments. The first and earliest framework is set out in Klein-Woolthuis, Lankhuizen and Gilsing (2005). Wieczorek and Hekkert (2012) developed the second framework in the context of technological innovation systems. In both frameworks, the diagnosis of systemic problems guides the formulation of systemic instruments. Where the frameworks differ is in their conceptualisation of an innovation system, which informs the approach to diagnosing systemic problems. Viewing the innovation system as an infrastructure, Klein-Woolthuis, Lankhuizen and Gilsing (2005) use structural analysis[35] to diagnose the systemic problems addressed by two projects in the Dutch cluster policy (1994-2002). From the viewpoint that an innovation system comprises of a set of functions, Wieczorek and Hekkert (2012) advocate the use of functional analysis to identify systemic problems and structural analysis to inform the design of interventions that address the identified weak or missing functions. The authors' coined this analysis scheme as 'coupled functional-structural' analysis. As previously mentioned, this study applies a functional perspective to the Irish agri-food innovation system, thus, systemic problems are defined as weak or missing functions within the innovation system. Therefore, the framework developed in Klein-Woolthuis, Lankhuizen and Gilsing (2005) is not suitable for analysing systemic problems. Wieczorek and Hekkert's (2012) framework is employed as it sets out specific guidelines on identifying

[35] The structural elements assessed include physical infrastructure, hard and soft institutions, interactions, and capabilities of actors and are assessed in relation to the needs of the actors in the innovation system.

and defining weak or missing functions. The framework advocates structural analysis of the functional problems to add deeper understanding to the systemic problem. This entails defining the functional problem in terms of weak or missing structural elements which is used to inform the design and implementation of systemic instruments. In the next section, the systemic policy framework set out in Wieczorek and Hekkert (2012) is summarised in three steps: innovation system analysis, formulating a systemic instrument and implementing change.

Step 1: Innovation System Analysis

In Wieczorek and Hekkert (2012), functional analysis is employed to assess the innovation system. This involves identifying and analysing the performance of the functional processes in an innovation system (Lamprinopoulou et al. 2014). However, Wieczorek and Hekkert (2012) argue that functional analysis of an innovation system is not sufficient. They relate a weak or missing function in an innovation system to a weakness in one of the four structural elements namely actors, interactions, institutions and infrastructure. Therefore, a change in a structural element causes changes in function activity. As such, Wieczorek and Hekkert (2012) emphasise structural analysis to add deeper understanding to the functional problems within the innovation system. Using the coupled functional-structural framework to assess the performance of an innovation system, Wieczorek and Hekkert (2012) outline eight types of systemic problems illustrated in Figure 4.2.

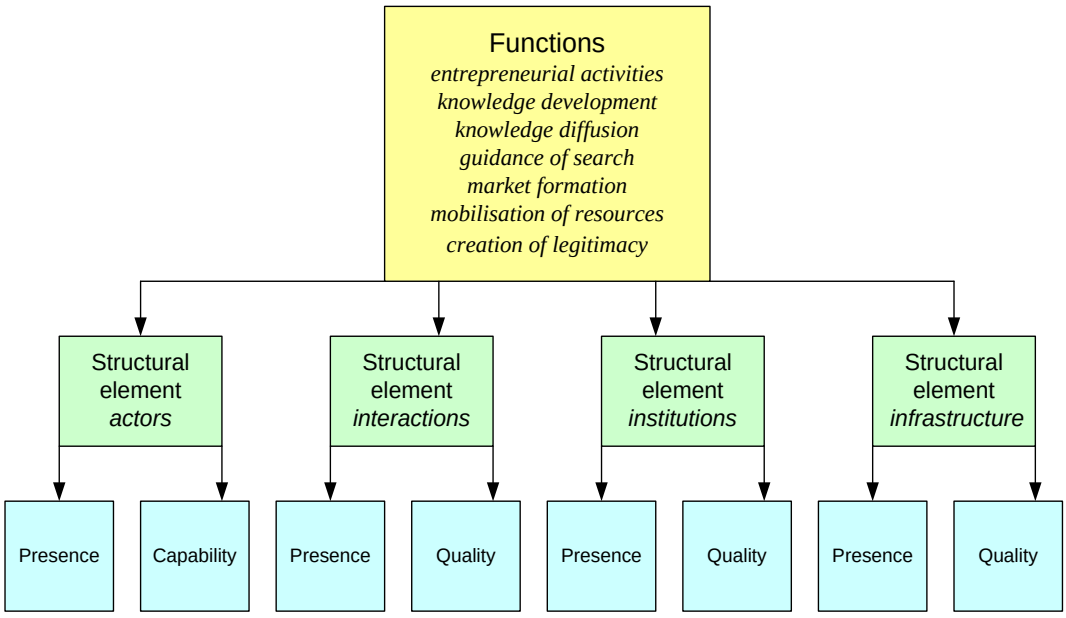

Figure 4.2 Using the innovation system framework to identify problems.

Source: Based on Wieczorek and Hekkert (2012)

Step 2: Formulating a Systemic Instrument

Wieczorek and Hekkert (2012) identify conditions which need to be fulfilled for systemic instruments to eliminate structural problems in the innovation system (Table 4.2). Wieczorek and Hekkert (2012) emphaise that operationalising one or more of these conditions is the goal of a systemic instrument. For clarity, a shorter label, which is underlined, is assigned to each condition listed in Table 4.2 below.

The need for specific conditions is linked to the weak or missing structural elements in the innovation system. This implies that a functional problem within an innovation system is addressed by a structural solution namely actors, interactions, institutions and infrastructure. However, in essence it is the activities of actors in the innovation system that resolves systemic problems (Edquist 2011). As such, policy makers cannot influence the process of innovation directly but can influence the environment in which the innovating firms operate (Edquist 2011). For example, if the government sets up an innovation centre, although they provide a space for actors to come together to share and create knowledge, they have a limited role in the successful development, diffusion or use of innovation. In this situation, the role of the government is to change, reinforce and improve the structural elements within the innovation system, which influence the activities of actors, i.e. that of facilitator of the innovation process.

In certain circumstances, policy makers may not be the only decision makers in an innovation system, or the most important ones. Smits and Kuhlmann (2002, p12) state that

‘*one should not overestimate the instrumentalist power of public policy vis-à-vis other actors in complex policy-making arenas. ’State’ authorities in (regional, national, transnational) multi-actor arenas of innovation policy play an important, but not a dominant role’*.

Similar to other actors in a system, State agencies do not have a panoramic view of system problems nor can policy makers fully rely on their past experience to resolve a system problem (Sabel and Zeitlin 2012; 2008). Smits and Kuhlmann (2002) suggest that identifying and solving the problems within an innovation system may not be the role required of policy makers. The authors’ suggest that the role required might be that of mediator.

Table 4.2 Formulating systemic instrument goals based on structural problems.

Structural problem	Nature of problem	Systemic instrument goals
Actors	Presence	Stimulate and organise participation of actors Actor participation
	Capability	Create space for actors' capability development Develop capability
Interactions	Presence	Stimulate occurrence of interactions Stimulate interactions
	Quality	Prevent too strong and too weak ties Appropriate ties
Institutions	Presence	Secure presence of (hard and soft) institutions Securing institutions
	Quality	Prevent too strong and too weak/ stringent institutions Appropriate institutions
Infrastructure	Presence	Stimulate physical, financial and knowledge infrastructure Stimulate infrastructure
	Quality	Ensure adequate quality of infrastructure Quality infrastructure

Source: Adapted from Wieczorek and Hekkert (2012)

Step 3: Implementing Change

Operationalising conditions to eliminate systemic problems and support system innovation are the goals of systemic instruments. Wieczorek, Hekkert and Smits (2011) suggest ways to operationalise each condition, which are listed in Table 4.3. Furthermore, Wieczorek and Hekkert (2012) list traditional policy instruments to use for that purpose.

Table 4.3 Operationalising conditions to achieve goals.

Goal	Operationalising conditions	Traditional policy instruments
Actor participation	Facilitate a process in which actors are receptive to new ideas and/or an argumentative process where actors become aware of the assumptions on their own	A facilitator role for government, clusters, public private partnerships, public debates
Develop capability	Stimulate interaction, experimentation and voluntary exchange of knowledge, R&D to stimulate learning	Foresights, road mapping, scenario development workshops, education and training programmes
Stimulate interactions	Coordinate actor information levels, level off of societal communication codes, moderate, provide negotiation conditions, manage expectations, orchestrate conflicting interests, create reliability and trust to overcome uncertainty, reframe actors' perspectives, build bridges between actors, and create common consensus	Moderators and bridging instruments such as cooperative research and technology programmes, and collaboration and mobility schemes
Appropriate ties	Provide long term perspective, vision, and openness to new ideas and provide solutions to facilitate structural change	Timely procurement (strategic, public R&D), demonstration centres, loans/tax incentives for innovative projects or new technology applications, venture capital
Securing institutions	Government can play a role in setting out regulation, patent laws, and voluntary agreements etc… to facilitate creation of new markets. Soft institutions (customs, normative values) follow hard institutions and have a role in facilitating change. Once institutions are adopted they shape human behaviour.	Regulation (public, private), limits, obligations, principles, norms, patent laws, standards, taxes, non-compliance mechanisms, customs, normative values
Appropriate institutions	Encourage actors to act to prevent too rigorous institutions (as they hinder innovation) and too weak institutions as may decompose the innovation system or prevent new systems from being built.	Awareness building measures, information and education campaigns, public debates, lobbying, voluntary labels, voluntary agreements, customs, normative values
Stimulate infrastructure	Support physical and knowledge infrastructure causing systemic problems	R&D grants, taxes, loans, schemes, funds (institutional, investment, guarantee), public research labs
Quality infrastructure	Ensure strategic knowledge is available and accessible.	Foresights, trend studies, roadmaps, intelligent benchmarking, SWOT analysis, industry and cluster studies

Source: Adapted from Wieczorek Hekkert and Smits (2011) and Wieczorek and Hekkert (2012)

Once again, to avoid confusion with the terminology, the three steps involved in the implementation of systemic instruments á la Wieczorek and Hekkert (2012) are summarised in Figure 4.3. The first step involves identifying the functions and their performance in the innovation system. The second step entails categorising missing or weak areas in terms of the performance of structural elements namely actors, interactions, institution or infrastructure. The third and final step involves categorising the structural problem as a presence or quality issue.

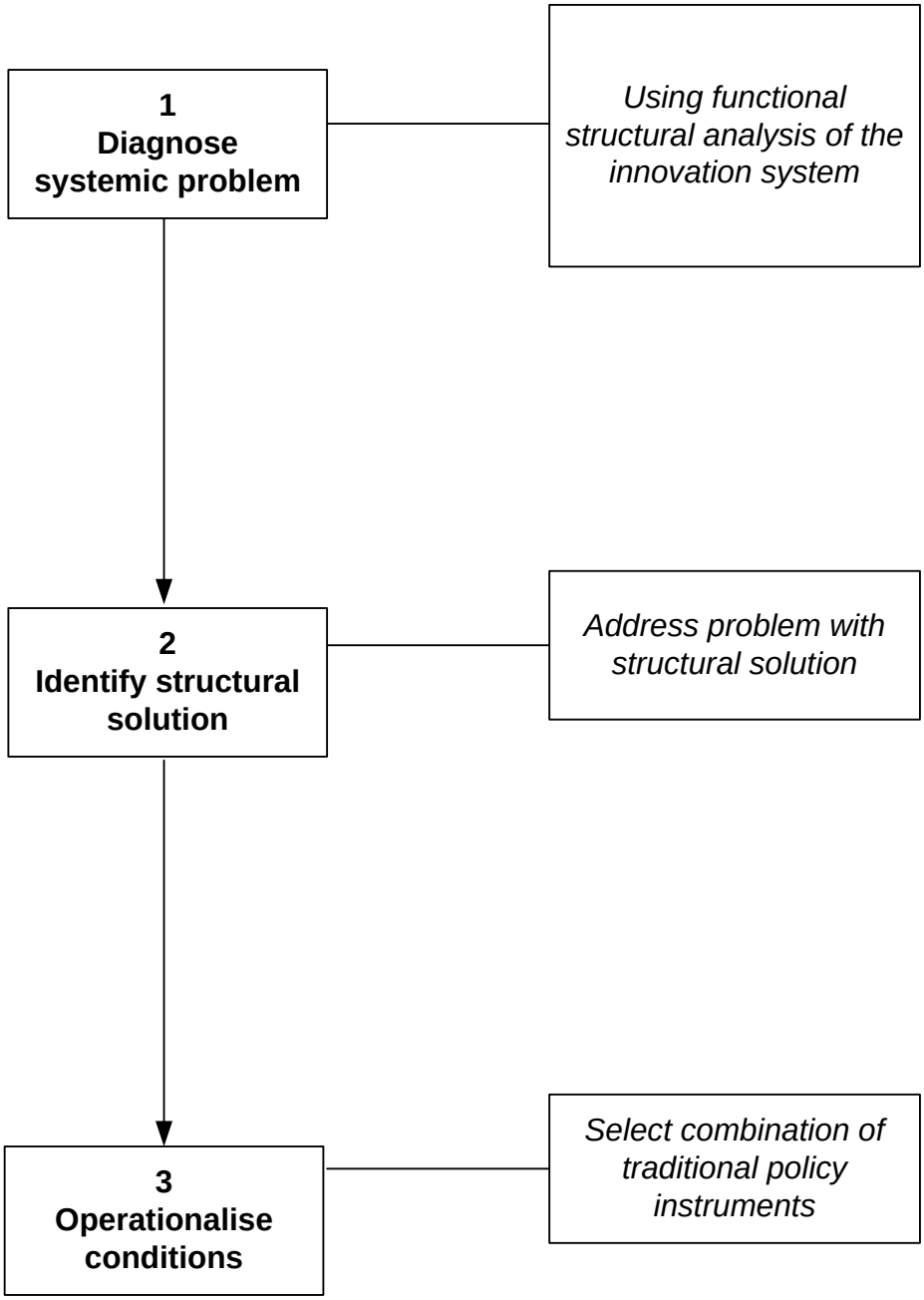

Figure 4.3 Systemic policy framework.

4.3 Research Question

To understand and influence the use of systemic instruments in policy making, it is important to understand how they operate. Wieczorek and Hekkert (2012) and Wieczorek, Hekkert and Smits (2011) provide guidance on policy tools to implement specific systemic instrument goals. There are no empirical applications of their framework. This study builds on that work by examining the implementation of two systemic instruments in an agricultural context. Having evidence on the implementation of systemic instruments provides policy makers with an approach to stimulate and achieve system wide change.

The aim of this study is to explore the potential of the systemic policy framework, set out in Wieczorek and Hekkert (2012). The findings guide policy makers specifically in relation to the design and implementation of systemic instruments. The two systemic policies focused on in this study are sustainable food production and the development of functional foods. Conceptualising the innovation system of the Irish agri-food industry as a set of functions, this study explores the implementation of two systemic instrument goals in the Irish agri-food industry. From a review of the two systemic policies, the creation of legitimacy around sustainable food production and knowledge development in functional foods are identified as functional weaknesses in the Irish agri-food industry. The research question asked in this study is *how are systemic instruments implemented in the Irish agri-food industry?* The coupled functional-structural framework developed in Wieczorek and Hekkert (2012) guides the inquiry as follows.

- *What structural elements are causing problems in achieving systemic policy objectives in the Irish agri-food innovation system?*
- *How are these structural problems addressed?*
    - *What tools are used to implement the structural solution?*
    - *Why are these tools used?*

4.4 Irish Agri-food Case Studies

The Irish agri-food industry is the empirical setting for this study. The agri-food industry provides a complete empirical context to address the questions raised around the problem of operationalising conditions to achieve systemic instrument goals. Two systemic policies are identifiable in the Irish agri-food industry.

The primary purpose of this study is to understand how systemic instrument goals are implemented. A secondary outcome of the study is to explore Wieczorek and Hekkert's (2012) systemic policy framework drawing on the implementation of two systemic

instruments. The study takes a case study approach. The two cases were chosen to provide insight into the experience of implementing systemic instruments. Prior to data collection, the author's knowledge of the agri-food industry suggested that systemic instruments to address problems in the innovation system would be found in the empirical setting, which was later confirmed by the data. In this section, the systemic instruments and the problems they address are discussed.

Systemic Objectives of Irish Agri-food Industry

The two systemic policies focused on in this study are sustainable food production and the development of functional foods, as these areas were identified as two priority areas for the Irish agri-food industry (Research Prioritisation Project Steering Group 2012; Department of Agriculture Fisheries and Food 2010a). Furthermore, their importance is emphasised in Ireland's National Recovery Plan[36] 2011-2014, which prioritises

'*investing in research, providing what consumers want, applying lean manufacturing techniques and ensuring we have the scale at every level to maximise cost competitiveness. There must also be a focus on environmental sustainability, while continuing to support and develop primary production. We must build on our green image and market'* (Department of Finance, 2010, p48).

To achieve these each of the policy objectives a network of actors comprising of research institutions, private firms and State agencies was formed. This depicts system innovation as a triple helix model of innovation defined in Etzkowitz (2008). The objective of the interconnected network is to provide a platform that can produce, transfer and apply new knowledge in response to the policy objective. The actions to achieve both objectives were set out by State agencies. Bord Bia[37] was the State agency that coordinated and developed a programme (launched in 2012) to support transition to sustainable food production, called Origin Green (OG). Enterprise Ireland[38] was the State agency that coordinated and co-developed a programme (launched in 2008) for research and development around functional foods, called Food for Health Ireland (FHI).

[36] An action plan for Ireland's recovery to sustainable growth

[37] Bord Bia is a semi-state body reporting to the Minister for Agriculture, Food and Fisheries.

[38] The government body concerned with supporting economic growth, regional development and employment.

4.4.1 Identifying Functional Problems

1. Creation of Legitimacy

Sustainable food production across the agri-food industry is now recognised as a way to sustain and improve the competitiveness of the industry as a whole (Dowling, Donoghue and Curtin 2009). This is based on the increased commitment of customers to sustainable production (Cotter 2012). Bell and Shelman (2010) emphasise the need for the Irish industry to build credibility around its green credentials. The authors' argue for action to develop a brand around Ireland's 'green image' to satisfy this rising demand of sustainable food production. The failure to create legitimacy among agri-food customers is determined as a functional problem in the innovation systems literature. This relates to action to counteract the resistance to change to sustainable food production.

Bord Bia, the Irish Food Board, responded to the failure to create legitimacy by developing a programme with the remit to improve practice and gain commitment to sustainable food production across the Irish agri-food industry. The challenge is for the industry to work to achieve the production targets set out in Food Harvest 2020[39] in a way that does not negatively impact the environmental, economic, and/or social dimensions of the industry (Research Prioritisation Project Steering Group 2012).

In its efforts to create legitimacy around the sustainable production of food in the Irish agri-food industry, OG an integrated approach to this problem, can be identified as a systemic instrument. Sustainable food production requires commitment from all producers in the supply chain. OG operates to support the replacement of existing production regimes in the Irish agri-food industry with more sustainable production practices (in terms of environment, economic and social).

2. Knowledge Development

Functional foods are foods that serve a purpose beyond basic nutrition by promoting health or reducing the risk of certain types of diseases (Research Prioritisation Project Steering Group 2012). These food types are high value products. To improve returns to the Irish agri-food industry, increasing the production of high value products was listed as a priority in the Enterprise Ireland Transforming Irish Industry 2008-2010. This led to Enterprise Ireland, in collaboration with industry and academic partners, establishing the industry-led functional food centre, FHI. The research programme was formulated by industry and implemented jointly by academic and industry partners.

[39] The national strategy guiding the activities of the Irish agri-food and fisheries industry to the year 2020

In the context of increasing the production of functional foods, FHI can be identified as a systemic instrument. More specifically, the production of functional foods requires research and development (R&D), to enhance food products[40] through the application of science and technology. Knowledge development processes that are weak and/or missing in an innovation system are determined a systemic problem. FHI was set out as a research programme to build and develop Irish capabilities in the area of functional foods. This establishes FHI as a systemic instrument, an integrated approach to address the weak process of knowledge development in the area of functional foods, in the Irish agri-food innovation system.

To summarise, OG and FHI are two systemic instruments operating in the Irish agri-food industry. The cases signify the emergence of system processes to address problems that overwhelm hierarchical governance and 'command-and-control' regulations within the innovation system (Sabel and Zeitlin 2012; 2008). Table 4.4 details the systemic instruments, in terms of the systemic problem they are addressing to achieve systemic policy objectives, using the systemic policy framework. Government bodies play a role in establishing both instruments however; their role in developing the programmes differed. The organisation and agenda for OG was undertaken by Bord Bia, whereas, Enterprise Ireland organised the functional foods programme, the industry and academic partners set out the agenda for FHI.

Table 4.4 OG and FHI in the systemic policy framework.

Systemic Policy	Systemic Problem	Systemic Instrument
Sustainable food production	Creation of legitimacy	OG
Development of functional foods	Knowledge development	FHI

4.4.2 Data: Collection and Analysis

The research inquiry was guided by the approach set out in Wieczorrek and Hekkert (2012) to identify and implement systemic instrument goals. Two sources of data were used: document analysis and interviews. The data was collected over the period February 2013 to August 2013. An overview of the data collection and analysis undertaken is presented in Table 4.5.

[40] Infant formula, dairy spreads, yogurts and cheese are some of the products that are being enhanced using the research results to help maintain health and alleviate conditions associated with serious diseases

The document analysis was used to identify the goals of the systemic instruments, OG and FHI. Multiple sources of evidence, in the form of a variety of documents, were used to reduce the potential of author bias influencing the findings. The documents used for each case are listed in Appendix C. The findings informed the interview questions posed to the interviewees. In addition, they provided a stable source of information to confirm and clarify contextual topics mentioned during interview.

Two interviews were carried out, one interview for each systemic instrument to understand the experiences of the individuals responsible for the design and implementation of the systemic instruments. The interviewees were selected for interview due to their role as programme coordinator. Both interviews lasted between 30-40mins. The interview schedule is set out in Appendix C. The interviews were digitally recorded and transcribed verbatim. Each audio was organised into a single profile document.

Table 4.5 An overview of the data collection and analysis undertaken in this study.

Data Collected	Analysis Approach
Document Review: Programme strategies, programme development plans, (n=5) were reviewed to define the activities of the systemic instruments (Research Question 1)	The activities associated with addressing the functional problem were examined to diagnose the structural problem that each systemic instrument is addressing
One interview with the coordinator of each systemic instrument to define the approach to implementing systemic instrument goal identified in stage 1. (Research Question 2)	The approach to implementing the systemic instrument goals was codified[41] to distinguish the policy tools and their roles in operationalising the conditions

The findings (section 4.5) are divided into three sections. The first section (section 4.5.1 Findings: Structural Problems) identifies the structural solutions to the systemic problems of creating legitimacy and knowledge development in the Irish agri-food innovation system. These solutions are the systemic instrument goals. Section 4.5.2 Findings: Operationalising Conditions – Creation of Legitimacy and Knowledge Development

[41] This involved descriptive coding followed by grouping codes into categories. These categories were labelled and reviewed for connections.

outlines the policy instruments used to implement the systemic instrument goal. In section 4.5.3: Overview, a summary of the findings from each case is discussed.

4.5 Findings

4.5.1 Findings: Structural Problems

In this section, the findings from the document analysis are used to outline the structural problem in the Irish agri-food innovation system that each systemic instrument is addressing. First, the findings for the systemic instrument OG, integrated to create legitimacy on sustainable food production are presented. Second, the findings for the systemic instrument FHI, integrated to improve knowledge development in the area of functional foods are presented.

Creation of Legitimacy

OG is the national sustainability programme for the Irish food and drinks industry. Using the findings from the document analysis, missing institutions around sustainable food production can be identified as a structural problem in the Irish agri-food industry. This determines the goal of the systemic instrument is to secure the presence of institutions for sustainable food production, by means of the systemic policy framework (Table 4.6). Institutions are an important determinant of innovation, which individually and collectively work with the other structural elements to influence the environment for innovation (Bergek et al. 2008; Edquist 2006; World Bank 2006). More specifically, the role of institutions is to influence actor behaviour and interactions, which is fundamental to achieving sustainable production across the Irish agri-food supply chain (Lester and Piore 2004). Institutions[42], in the context of an innovation system, are defined as the rules of the game that influence actor behaviour and interactions. They are shaped by the actors in the innovation systems although they can be perceived by other actors as structures (Van Mierlo and Arkesteijin 2009). They are distinguished between hard and soft. Hard institutions include rules, laws, voluntary agreements, patents, regulations and instructions. Soft institutions include customs, norms, habits and routines. The identified activities of OG that led to determining the structural problem as missing institutions are outlined in this section.

[42] The concept of institutions has different interpretations in the innovation systems literature. It can represent the rules of the game or organisations in an innovation system. In this thesis institutions refer to the rules of the game as defined by Edquist (2006) and not organisations.

Table 4.6 OG in terms of the systemic policy framework.

Systemic Policy	**Systemic Problem**	***Systemic instrument***	**Structural Problem**	**Systemic instrument goal**
Sustainable food production	Creation of Legitimacy	*OG*	Missing institutions	Secure presence of institutions

Activities of the systemic instrument, OG

OG, launched in June 2012, operates to support change in existing food production regimes to more sustainable regimes (in terms of environment, economic and social). The objective of the programme is to motivate and guide supply chain contributors, across farm and food manufacturing levels, in the sustainable production of food. Sustainable production is defined as monitoring greenhouse gas (GHG), emission energy conservation, water management, biodiversity, community initiatives and health and nutrition. The programme is coordinated, delivered and marketed in export markets by Bord Bia. The State agency developed the programme and are marketing it as a business to business initiative (Bord Bia 2013b).

Activity 1: Monitoring sustainability performance

The performance and on-going improvements of farms and food companies in relation to sustainable food production is monitored. At farm level, OG monitors participation in Bord Bia Quality Assurance Schemes operating in beef, lamb, pig, poultry, eggs and horticulture within developments of a similar scheme for dairy underway (Shelman and Bord Bia 2013). The Quality Assurance Scheme is the programme that sets out the standards for the production of a food product (Bord Bia 2013d). It covers all steps in the food chain from production to final packaging for sale to the end user. The product and/or its producers are audited to ensure that production is in accordance with the standards set out. There are three basic components to a Quality Assurance Scheme: standards, audits and certification (Bord Bia 2013d). At farm level, approximately 42,700 farmers were certified members of a Quality Assurance Scheme for their specific sector in 2012 (Cotter 2012) (Table 4.7).

Table 4.7 Number of farms, differentiated based on sector, certified under Quality Assurance Scheme and the estimated contribution to total sector production.

Quality Scheme	Farms Certified	Estimated Production
Beef	32,0000	75%
Lamb	8,500	45%
Pig	360	95%
Poultry	1,200	95%
Eggs	350	97%
Horticulture	300	50%

Source: Cotter, A. (2012)

The range and scale of farm and food manufacturing activities differ across the agri-food sectors; therefore, it is difficult to set a specific benchmark that formally certifies the actions of all agri-food producers. Consequently, at food manufacturing level Bord Bia verifies improvements in delivering specific company targets, using independent auditors. Individual company performance is assessed relative to their specific targets (Bord Bia 2013b).

For food manufacturing companies, there are a number of steps to becoming a member of OG: the registration of interest, the submission of a formal application, and membership. The benefit of membership is that it allows the company to use all OG communication and branding material and includes the company in Bord Bia's future communication campaigns in international markets. In June 2013, 260 agri-food companies had registered as members of programme and 22 of them had become full members (Bord Bia 2013c). On achieving membership, participants are required to formulate a plan that sets out actions and targets for improving their sustainability performance. Once submitted each plan is assessed by an independent third party appointed by Bord Bia.

Activity 2: Developing measures on sustainability

From the analysis of the documents, it was identified that measures for sustainable food production that encompasses production activities from farm to fork do not exist. OG is continuously working to address this gap by combining new and existing tools that measure aspects of sustainability performance namely environmental, economic and social. The tools developed are detailed in Table 4.8.

Table 4.8 The tools used to measure aspects of sustainable food production from farm to fork.

Title	Original Purpose	Sustainability Purpose	Developers
The Carbon Navigator	Farm management	Enables dairy and beef farmers to set improvement targets in key management areas and view cattle enterprise outputs in terms of environmental[43] and economic[44] performance	Co-developed by Teagasc and Bord Bia
Quality Assurance Schemes	Food Quality Standard	Provides standards and measures (through routine audits and certification) on production of food produce	Bord Bia
Carbon Footprint	Farm management	Quantifies the carbon footprint of a specific produce (beef, milk) used in navigator calculations	Co-developed by Teagasc and Bord Bia
Green Business	Company resource efficiency assessment	Assess resource efficiency improvements relating to waste prevention and reductions in water and energy consumption	Environmental Protection Agency (EPA), under National Waster Prevention Programme
Sustainability Charter	Programme to set out, implement and report on company sustainability practices	Purposefully developed for OG	Bord Bia

Source: Author, using Teagasc Working Group on Greenhouse Gas Emissions (2011); Bord Bia (2013c); Crosson (2012); Bord Bia (2013a).

[43] Measured in terms of potential GHG impact
[44] Measured in terms of effect on production costs

At food manufacturing level, the OG Sustainability Charter guides the design, implementation and assessment of company sustainability practices (Bord Bia 2013b). The Charter is formulated by individual companies and set out company specific targets. The Charter is continuously updated to report on-going progress in achieving short, medium and long term goals (Bord Bia 2013b). The four steps[45] involved in its development are explained in Table 4.9. Examples of targets set out, in areas of raw material sourcing, manufacturing process and social sustainability, are listed in Table 4.10. It is evident that the activities at farm and food manufacturing level are linked, as company participation requires sourcing raw materials from certified members of approved farm sustainability schemes.

Table 4.9 Explanation of the steps involved in developing a sustainability charter.

Steps	Explanation
Step 1: Decide on target areas	Participant decides on at least two target areas Participant decides one 'stretch area'
Step 2: Agree baseline period	Choose reference period from which improvements can be measured Baseline period of up to two year prior to registration
Step 3: Set timeline and targets	Short, medium and long term targets set for each area Justification for 'stretch area'
Step 4: Annual progress report	Sign commitment to report annually on each target Communicate progress to targets being ahead, on schedule to behind

Source: Author, using Bord Bia (2013a)

[45] The completion of each step requires verification by an independent auditor.

Table 4.10 Explanation of target areas in sustainability charter.

Target area	Examples
Raw material sourcing	- Commitment to source from suppliers with recognised certifications - Development of sustainability initiatives with suppliers
Manufacturing process	- Energy - Emissions - Water - Waste - Biodiversity
Social sustainability	- Health and nutrition of products - Company role in their local community - Employee Wellbeing

Source: Author, using Bord Bia (2013a)

Knowledge Development

FHI is a functional foods R&D programme in the Irish agri-food industry. The weak interactions between the academia and industry environments around knowledge development for functional foods are identified as a structural problem in the Irish agri-food industry Research Prioritisation Project Steering Group 2012; Department of Agriculture Fisheries and Food 2007). This determines, by means of the systemic policy framework (Table 4.11), that the goal of the systemic instrument, FHI, is to stimulate interactions. Similar to institutions, interactions are one of the four structural elements of an innovation system. This implies that from an innovation systems perspective, interactions are a determinant of innovation. Their role is to facilitate knowledge exchange and learning between actors (Wieczorek and Hekkert 2012; Edquist 2006; World Bank 2006; Klein Woolthuis Lankhuizen et al. 2005). Interactions encompass both formal (networks, partnerships) and informal (peer groups) and can be analytical or interpretative in nature as distinguished by Lester and Piore (2004). The activities identified that define the structural problem are outlined in this section.

Table 4.11 FHI in terms of the systemic policy framework.

Systemic Policy	**Systemic Problem**	***Systemic instrument***	**Structural Problem**	**Systemic instrument goal**
Food for Health	Knowledge development	*FHI*	Weak interactions between actors	Stimulate interactions

Activity 1: Established as a public private partnership

The strategic objective of FHI is to build long term industry-academic networks in the agri-food industry (Henchion and Sorenson 2013). This addresses the on-going challenge to integrate the research base and industry in the Irish agri-food industry for knowledge development (Research Prioritisation Project Steering Group 2012; Department of Agriculture Fisheries and Food 2007). This is of particular importance in the area of functional foods which rely on new science and technolgy to enhance food products (Research Prioritisation Project Steering Group 2012).

This led to establishing FHI as a public private partnership between academia and industry. The academic partners include a consortium[46] of Irish Public Research Organisations (PROs). It includes University College Cork, University College Dublin,

[46] The research consortium was formed following a public research call in 2006 seeking expressions of interest from Irish Public Research Organisations to participate in an industry-led functional food centre (Henchion and Sorenson 2013).

University of Limerick, and Teagasc. The industry partners are Dairygold Food Ingredients, Glanbia Nutritionals, Carbery and Kerry Ingredients Ireland.

The aim of FHI, established in 2008, is to develop new skills and technologies in the area of functional foods which is achieved by combining the scientific expertise of academia and product development expertise of industry to ensure the products developed have market feasibility (Hallihan 2013).

Activity 2: Partners responsible for governing and developing programme activities

Industry was allocated responsibility to set out the research agenda for the programme. The four areas identified were infant development, metabolic health, infection, and immunity and healthy ageing. The R&D process is illustrated in Figure 4.4.

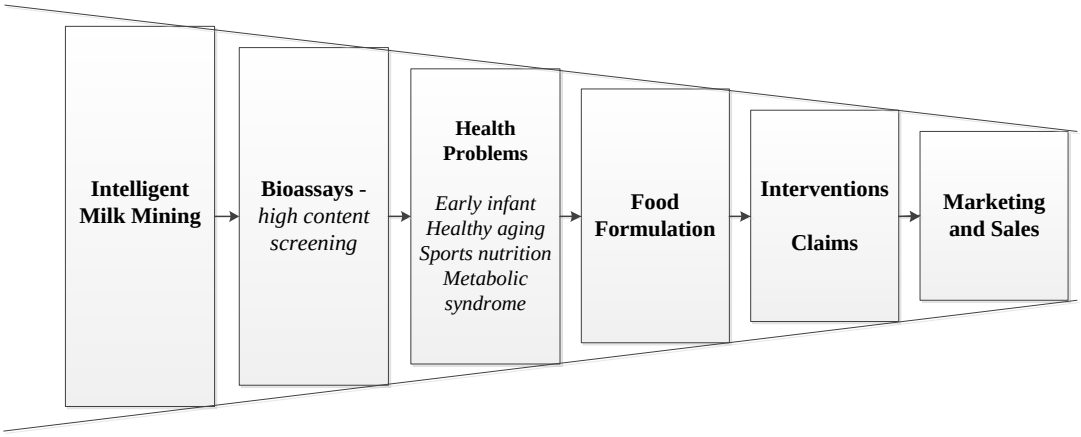

Figure 4.4 R&D process in FHI**.**

Source: Author, adapted from presentation by a Carbery representative during Agri-Food Graduate Development Programme '*Innovation in the Bioeconomy*', University College Cork, February 2013.

The contributions of academic and industry partners relates to R&D personnel and funding in the case of industry partners. In total, FHI comprises of a team of seven full time staff located at two locations, Dublin and Cork (Henchion and Sorenson 2013). The programme is co-funded by Enterprise Ireland and the four industry partners, receiving €19.3 million funding from Enterprise Ireland and €3 million from industry (Henchion and Sorenson 2013; Department of Jobs Enterprise and Innovation 2012). Due to the level of public funding, the consortium of research institutes own the intellectual property with the four industry partners having equal right to license the products developed (Hallihan 2013).

The academic and industry partners govern the programme collectively. However, as the largest financial contributor to FHI, Enterprise Ireland holds a right to have a representative sit on board or committee meetings to oversee matters. The board, which meets four times annually, comprises of representatives from each of the PROs and industry partners. The CEO and chairperson were selected from the private industry (Henchion and Sorenson 2013).

Implications of Findings

In this section, the findings from the review of the documents confirm the goals of the systemic instruments OG and FHI as securing the presence of institutions and stimulating interactions between actors (Table 4.12)

Table 4.12 OG and FHI in terms of the systemic policy framework.

Systemic Policy	**Systemic Problem**	***Systemic instrument***	**Structural Problem**	**Systemic instrument goal**
Sustainable Food Production	Creation of legitimacy	*OG*	Missing institutions	Securing the presence of institutions
Food for Health	Knowledge development	*FHI*	Weak interactions between actors	Stimulate interactions

In the next section (section 4.5.2 Findings: Operationalising Conditions – Creation of Legitimacy and Knowledge Development), the findings from the interview data address how the structural solutions are implemented. More specifically, the research question answered is: *What tools are used to implement the structural solution and why*?

In the case study of OG, the analysis focused on what policy tools were used and why in securing institutions on sustainable production in the Irish agri-food industry. Securing the presence of institutions involves first developing hard institutions as soft follows hard (Wieczorek and Hekkert 2012). The systemic policy framework emphasises a role for government in the development of hard institutions.

In FHI, the analysis focused on what policy tools are used and why in stimulating interactions between academic and industry environments in functional food R&D. To stimulate the occurrence of interactions between actors, the systemic policy framework

emphasises the encouragement of knowledge exchange, building bridges between actors, reframing actors' perspectives and creating consensus among actors.

4.5.2 Findings: Operationalising Conditions – Creation of Legitimacy and Knowledge Development

This section discusses the findings from the interviews on the policy tools used by the instrument coordinators to implement the structural solutions for the functional problems in the Irish agri-food industry. First, the findings that address the creation of legitimacy around sustainable food production are presented. Second, the findings that address weak knowledge development in the area of functional foods are outlined.

Creation of Legitimacy

The interview data was used to examine the process to implement the structural solution, securing institutions on sustainable food production, to investigate the tools employed.

Factors influencing the selection of policy tools

The goal of OG is to provide proof around Ireland's green credentials. This is viewed as a way to sustain competitiveness and relevancy in global supply chains. PC_OG emphasises the importance of this for the Irish agri-food industry '*we have to be in a position to put our best foot forward when it comes to it*'. The choice of policy tool is a function of: its role in gaining agri-food producer commitment and its role in establishing credibility among agri-food customers.

Commitment from all producers across the supply chain to implement the targets set out is important. The achievement of sustainable food production is dependent a commitment from individual producers to improve sustainability practices. PC_OG, explains how the Sustainability Charter of a food companies demonstrates the commitment of Irish agri-food producers

'*you can set a system in place that we'll say we'll commit that x% of our farmers will be … Y% in year two etc. so you don't have to wait till there's 100% in by any means but as long as you show the goal if you like … commitment is there to source as much as possible from those farms that's what we're looking for really'*.

This demonstration of commitment to sustainable food production helps establish credibility among agri-food customers.

Agri-food customers are increasingly demanding proof on sustainable food production practices. This is realised through interaction with agri-food customers. PC_OG explains learning from customers' demands

‘*interaction with customers in international markets we started out in the last five or six years in particular getting asked an awful lot more about what are you doing in terms of sustainability from an environmental point of view, obviously from the whole social aspect of sustainability point of view as well, what are you doing in Ireland? What have you to offer? What proof can you show us in this area? What are you doing to improve your performance over time and can you show us facts and figures and demonstrate to us what you’re doing?’*

The interview confirmed that there are two issues relevant to the programme OG. The first is the development of sustainable food production by changing production practices throughout the value chain. The second is the identification of ways to secure the associated green credentials for consumers of agri-food products.

Policy tools used in securing institutions around sustainable food production

The development of institutions on sustainable food production, across farm and food levels, is an ongoing process, directed by Bord Bia. To operationalise the condition a number of policy tools are employed. The choice of tool is influenced by its ability to reinforce commitment among food producers and credibility among customers of sustainable food production in the Irish agri-food industry. The tools used to secure the presence of institutions are listed in Table 4.13. The activities of agri-food producers and agri-food customers’ secure the presence of institutions on sustainable production. More specifically, the sustainability demands of agri-food customers inform the institutions needed in the Irish agri-food innovation system. These institutions listed in Table 4.14 help create legitimacy in the innovation system.

Table 4.13 The policy tools used by OG secure institutions around sustainable food production.

OG methods	Policy tool
- Carbon Navigator tool - Farm advisors - Sustainability Charter Workshop - Drafting a Sustainability Charter	Awareness building measures
- Senior management in company - Linking farm and food manufacturing activities	Compliance mechanisms
- Independent auditing programmes	Regulation

Table 4.14 The role of policy tools in creating legitimacy around sustainable production.

Policy tool	Institutions	Creation of legitimacy
Awareness building measures	Common values on production	Commitment Credibility
Compliance mechanisms	Voluntary agreement	Commitment Credibility
Regulation	Standards	Commitment Credibility

Customer demands for sustainable produce are rising. Therefore, building awareness of OG among customers has importance for the both individual members and the Irish agri-food industry as a whole. This role was undertaken by Bord Bia which encompassed responsibility for marketing OG, in export markets, on behalf of members of Origin Green.

The initial approach applied to build awareness was described by PC_OG as '*not saying too much too early… until a critical mass of companies registered*'. However, at the time of interview, 260 companies had registered with the programme and Bord Bia had begun to increase awareness of OG among key customers in the export market. PC_OG explains

'*now we're happy we're at the stage where we have that critical mass so what we're doing is we're picking key markets and key customers within those markets and going to meet them and explaining one to one exactly what the programme is trying to do*'.

In this next stage, a basic level of understanding among customers on how the programme operates at both farm and food manufacturing level is being established, so that customers are aware when members discuss their sustainability plans in terms of OG. PC_OG explains the process as

'*going to meet them and explaining one to one exactly what the programme is trying to do, how it operates at farm level, how it operates at food manufacturing level so then they'll have a base level awareness of the programme. So if a member company then goes into them and says well you've heard of Origin Green, they say yes we have, well this is my plan as part of Origin Green this is what we're doing in terms of sustainability* '.

The final phase of marketing the programme will involve presenting customers with the collective achievements of members. PC_OG explains that

'*in a year's time we want to be saying, well this group of companies have now been members for a year this is what they've achieved and this is what they are going to achieve in the next three years*.

The three policy tools employed in securing institutions on sustainable food production are discussed in the following section.

Policy Tool 1: Building Awareness

Building awareness among food producers on sustainable food production employs the use of informative type tools. These tools facilitate learning among actors to bring about change in their activities. Four tools are used: the Carbon Navigator tool, Farm Advisory, a Sustainability Charter workshop and drafting a Sustainability Charter.

First, the Carbon Navigator tool is used as a measure to illustrate the link between sustainable and efficient production at farm level. Therefore, it builds awareness and acts as an incentive to implement sustainable production processes. The application of this tool enables a farmer to see potential of sustainability activities to influence GHG emissions and financial performance. PC_OG explains

'*the tool will allow them to see what that might do from a greenhouse gas mitigation point of view but more importantly what it could also do for the farmer's financial performance*'.

Furthermore, the results help a farmer set sustainability targets. PC_OG explains '*it allows the farmer to try and set targets for improving their performance under each of those five headings'.*

Second, farm advisors are used to build awareness among farmers. In the context of the dairy industry, PC_OG explains

'*milk advisors on the ground who are dealing with these farmers anyway, they're going to be critical in terms of building awareness of what exactly what the scheme is, how it works, what's expected of them. They're the ones that are going to ensure that farmers get over the line on this and the majority of farmers will have absolutely no issue'.*

Third, food manufacturers are informed about the programme at a Sustainability Charter workshop. The workshop is operated for newly registered food manufacturing companies and enlighten the participants on *' the structure of that scheme, how is it going to work,*

what will be looked for from you at audit time etc…' The aim of the workshop is to inform participants on

'*number one the justification for having a programme like this in the first place and number two exactly what we mean say by the charter or what's happening at farm level and what we require of them to include in their plan*'.

Fourth, drafting a Sustainability Charter shows members the value to the individual company and industry in complying with standards on sustainable production. After registering with programme, participants are invited to attend a half-day workshop delivered by Bord Bia. PC_OG explains

'*some come in thinking there's not a whole lot to it in terms of the detail and once they come along to workshops then things get a bit serious from that point on so it is taking time you know*'.

Upon completion of the workshop companies draft a plan PC_OG explains it can be

'*the first time they've actually sat down and really looked at the resources that they're using for the sourcing of products or what their role is in their local community so for them it's a big learning process*'.

Policy Tool 2: Compliance Mechanisms

Customers demand verification on sustainable food production. This was emphasised during discussions with customers in the development of the OG programme. The idea of OG was presented to customers and PC_OG explains that their response was that

'*as a concept Origin Green sounded good but it has to be much more than a name or a logo or a strap line it has to have substance behind it*'… '*one thing we've certainly found in talking to our customers is that level of verification whether it's at food manufacturing level or farming level was very important*'.

Customer demands for verification influenced the development of compliance mechanisms for agri-food producers. PC_OG emphasises its importance

'*one thing we've certainly found in talking to our customers is that level of verification whether it's at food manufacturing level or farming level was very important*'.

Two approaches are used to achieve compliance across food producers: agreement from senior management to implement Sustainability Charter and linking sustainability activity at farm and food manufacturing levels. The first approach involves gaining agreement

from senior management to implement the action plan set out in the Sustainability Charter. The importance of this was highlighted in the pilot programme[47]. PC_OG states

'the key thing really we found certainly is to get a commitment at a senior management level that this is the plan that we're going to implement. There's no point in giving the job of writing a plan to Tom or Joe or whoever it is and it's the job done tick the box and move on. That's not what this is about at all, it's about having a structure that in a year's time we're going to come back and get a proper report from that company to say well we said we were going to do the following these are the initiatives we said we'd complete in the year, this is how we've got on, we're on track on these we're ahead on schedule on these or we're behind on these'.

The second approach is linking the sustainability performance of a food company to the production activities of agricultural produce. Farms that are members of one of the suite of Quality Assurance Schemes have become part of OG. PC_OG explains that '*any farmer that's a certified member of our quality assurance schemes and has a sustainability assessment built in are now part of Origin Green*'. In the Charter, companies must state their commitment to source agricultural produce from Quality Assured farms. PC_OG explains showing commitment to source sustainably

'*you can set a system in place that we'll commit that x% of our farmers will be … Y% in year two etc. so you don't have to wait till there's 100% in by any means but as long as you show the goal if you like … commitment is there to source as much as possible from those farms that's what we're looking for really'.*

In addition to these approaches, OG is building an evidence database for the entire agri-food sector. Its efforts to aggregate the sustainability practices of the Irish farming sector, a network of organisations that collect farm level information is being development. Network actors include the Department Agriculture, Food and Fisheries and ICBF (Irish Cattle Breeding Federation). This network reduces the collection of information directly from farmers. PC_OG states that the data provides evidence on '*what is happening out on farms in terms of say water conservation or wildlife habitats whatever it is and building up that picture'*. The audit reports on food company progress to achieving targets set out in sustainability plan collectively provide evidence on how the agri-food industry is performing as a whole. Each sustainability plan includes their commitment to source sustainably produced agricultural produce. The ambition is that Bird Bia, who has responsibility for marketing the programme, will present collective achievements of the industry to customers. PC_OG explains that

[47] Nine Irish agri-food companies took part in a pilot programme in early 2012

'*in a year's time we want to be saying, well this group of companies have now been members for a year this is what they've achieved and this is what they are going to achieve in the next three years*.

Policy 3: Regulation

The development of a national standard on sustainable food production is an on-going process. It requires commitment from food producers and credibility among customers. To encourage commitment, OG is continuously developing measures and instructions on sustainable production to use at farm and food manufacturing levels. These measures and instructions guide improvements in sustainable performance. The performance and on-going improvements in sustainable production at farm and food manufacturing levels are regulated, using an independent auditing programme. Audits involve an annual review of progress to achieve targets. A farm level auditing process involves reviewing sustainability plans and achievement of targets. At manufacturing level the process involves an initial review of Charter set out and the annual review of progress to achieve targets.

The sustainability targets of farm and companies relate to their specific needs and constraints. Therefore sustainability targets differ. PC_OG explains that company plans

'*differ in length, differ in target areas that they've actually chosen within raw material sourcing, differ within the manufacturing process so it's really as we say at the workshop it's the company's plan it's not about having a plan that will qualify for Origin Green if you take that approach it's the wrong approach*'.

As plans differ, auditors engage directly with the farm or company to provide feedback on achievements. For example, PC_OG explains that '*<Auditors> and the company deal directly with each other in terms of clarifications or issues that they may see'.*

Knowledge Development

In this section, using the interview findings, the policy tools used to stimulate the occurrence of interactions, between academic and industry partners, in the area of functional foods, are listed and discussed. The interview data was used to examine the process to implement this structural solution to investigate the tools employed. The tools used to secure the presence of institutions are listed in Table 4.15.

Factors for Policy Tool Selection

In the early days of FHI, the level of interactions between the academic and industry partners involved was low despite being on the FHI board, intellectual property (IP) committee and steering group of together. From this starting point, the process involved in stimulating the occurrence of interaction was time consuming. PC_FHI explains

'industry is on the board with PROs they are on the IP committee, they are on the steering group committee, and in fact in FHI they are very hands on, but in the early days they were quite stand offish, by about one year, two years in the relationships began to develop and then you have this serendipitous nature, then additional little projects start to filter out that might not be core to FHI but that come on the side or the back of "ah you know, thought might be good for our chickens in <name of industry partner> that we could look at that elsewhere, can we do a project with you" and they go off and fund that themselves'.

Two factors inform the selection of the policy tools. They include:

- Ability to change the perspectives of actors to interact with other actors. These actors include industry and academic R&D competitors in the area of functional foods.
- Ability to address the current and emerging R&D needs and problems of actors in the area of functional foods.

These factors indirectly have a role in addressing the functional problem of knowledge development in the innovation system. Table 4.16 shows the role of each policy tool in stimulating interactions between actors and the influence this activity has on knowledge development in functional foods.

Table 4.15 The policy tools used to in FHI to implement the systemic instrument goal.

FHI methods	Policy tool
- Industry set R&D agenda - Flexible R&D agenda - Academia own IPRs	Incentives
- Support initiation of dialogue - Identify common objectives	Facilitator role

Table 4.16 The role of policy tools in stimulating knowledge development in the area of functional foods.

Policy tool	Stimulation of interactions	Knowledge development
Incentives	Initiating formal interactions	Change actors' perspectives Addressing actor needs and problems
Facilitator role	Formal leading to informal	Change actors' perspectives Addressing actor needs and problems

Policy Tool 1: Incentives

Incentives are established to motivate partners to interact. The formulation of the incentives was informed by the needs of each partner type. The incentives are in the form of benefits and rewards.

To motivate the industry partners to interact, initially with other industry partners and then with the academic partners, they were assigned the task of formulating the R&D agenda for FHI. It was identified, from previous interaction with the industry partners, that they '*like to be in a position to direct'* research programmes in line with their market needs. This required industry partners to co-develop the R&D agenda based on their collective needs. The industry partners did not engage with other industry or academic partners on a continuous basis. Interaction was initiated for problem solving only. PC_FHI explains '*they would go to sort a specific problem, some of them had done it before but in fact most of them hadn't'.*

The incentive is also used to indirectly reframe industry perspectives of previous experience in R&D programmes to help stimulate interactions. As in general, the foregoing experience of industry partners that had engaged with academia *'hadn't really got a good experience out of it'*. The R&D agenda set out is flexible to adapt to the changing needs of industry. PC_FHI explains that

'*industry needs change and you know even the fact that they dropped one or two of the modules and introduced others – the perceptions of industry change as well and how they deal with things, and that can be challenging at times'.*

Industry needs are informed by market demands on functional foods and rules and regulations on health claims made about food products. PC_FHI states that '*the lessons learned would be flexibility in approach because it is market led, because the market changes*'.

The motivation of academic partners to interact was a two stage process. First, it required encouraging the four Public Research Organisations (PROs), which submitted two proposals to the research call in 2006, to collectively submit one proposal. The second stage required encouraging interaction with industry partners in FHI. The ownership of the Intellectual Property Rights (IPRs) of outputs from FHI was employed to incentivise interaction. IPRs are a reward that was used to initiate and sustain a continuous level of engagement.

The change in the willingness of PROs to collaborate on research projects based on their rising need for additional revenue generation was identified. PC_FHI states that the PROs are '*all moving towards industry interaction and it is recognised and they all have their own policies for this type of thing now, so they are more amenable to it*'. The incentive was also used to keep the sometimes '*single minded*' PROs engaged in activity with commercial value not '*blue sky research for publication'*. PC_FHI explains

'*there is revenue generation for the colleges and in this particular sector they own the intellectual property so they can generate quite a good income if things work out for them*'.

Policy Tool 2: Facilitator

FHI implemented activities to develop and establish common consensus between the partners to support the occurrence of interactions**.** Facilitation was used to achieve this through the initiation of dialogue and identification of common objectives and needs among partners in the area of functional food R&D. The State agency Enterprise Ireland

is the facilitator. PC_FHI states role of agency is '*external player facilitating dialogue'.* Interview B characterises the process to build common census as

'*egos managed and persuaded and you know looking for commonality and showing you know international comparisons – so that takes a while – that takes a long time to build trust*'.

Facilitation was used to establish dialogue between industry participants to support the setting of the research agenda. PC_FHI explains the process as

'*facilitating dialogue with the industry participants individually and then collectively and forming a you know a consensus view on where the gaps are and what they need to do as a sector to move forward and then what would be beneficial for them to access individually they can take out or collectively what they can do together even through business interaction*'.

This was undertaken when it was identified that industry partners were unwilling to meet to co-develop the research agenda. PC_FHI explains that getting the partners in the

'*same room together was difficult because they did not want to talk openly, so one of the significant things that comes through this type of programme is this level of hidden or lack of openness early on'.*

Facilitation was also used to help the industry partners recognise areas of commonality in the setting out of the research agenda. This process is time consuming and slow. PC_FHI explains that the process involved

'*sitting in a room for months, can we work it out, we know you have an issue with this and maybe if we talk to somebody else and then suddenly the dawn of realisation do you know what we all have an issue in that, did you, I thought you had it sorted, no no no'.*

4.5.3 Findings: Overview

The structural elements causing the functional problems, of creating legitmacy and knowledge development are identified as missing institutions and weak interactions. Two systemic instruments OG and FHI address these system problems relating specifically to sustainable food production and the development of functional foods. This defines the systemic instrument goals as 1) to secure the presence of institutions and 2) stimulate interactions between appropriate actors respectively. A number of tools are used to achieve these goals. To secure the presence of institutions three tools are used: awareness building measures, compliance mechanisms and regulation. To stimulate actor interactions two tools were used: incentives and a facilitator. These findings are discussed in the next section.

4.6 Discussion

The case studies of OG and FHI illustrate the emergence of system processes, termed systemic instruments, to address problems within the Irish agri-food innovation system. Furthermore, the findings confirm that the process to address systemic problems requires joint action between research institutes, firms, and State agencies within interconnected networks with the capacity to produce, transfer and apply innovation. This provides evidence that system innovation is a triple helix, as defined by Etzkowitz (2008). Previous work of Wieczorek and Hekkert (2012), formulated an analytical framework, referred to as the systemic policy framework, to guide policy makers in the design and implementation of systemic instruments. Using the two case studies, this study confirms that the framework is useful for identifying problems within an innovation system and informing the design of appropriate systemic instruments. More specifically, the coupled functional-structural analysis is shown to be an appropriate policy making tool for identifying functional problems and designing structural solutions to address these problems.

The findings on how the systemic instrument goals are implemented show that the structural solutions inform the activities pursued by the systemic instruments. For example, the activities of the systemic instrument, OG, centre on securing institutions to create legitimacy among agri-food producers and customers on the sustainability of Irish agri-food products. Similarly, in FHI, efforts are focused on stimulating interactions between industry and academic partners to support new research and development in functional food produce. More specifically, the findings on operationalising conditions to achieve functional goals confirm the argument in Wieczorek and Hekkert (2012) and Wieczorek, Hekkert and Smits (2011) that a set of policy tools is used to implement a systemic instrument goal. Furthermore, the case studies provide empirical evidence that are confirmatory to the independent and collective influence of the policy tools on achieving systemic instrument goals, discussed in Wieczorek and Hekkert (2012) and Wieczorek, Hekkert and Smits (2011). The case studies findings reveal that the choice of policy tool reflects the nature of the problem identified, interactions with other tools and the contextual nature of the environment in which it is embedded. This confirms the theorecial suggestions on the role of policy tools in the implementation of systemic goals in Wieczorek and Hekkert (2012) and Smits and Kuhlmann (2004). The empirical findings add to this discussion by clarifying that the choice of tools reflects both the identified structural and functional problem. For example, as shown in Table 4.14, each policy tool used in OG namely awareness building measures, compliance mechanisms and regulation is selected to develop a specific type of institution i.e. common value on

production, voluntary agreement or standards. In addition, tool selection is based on an ability to 1) establish commitment among producers and 2) credibility among customers on the sustainable production of Irish agri-food. Similarly, in the case of FHI, incentives and facilitation play independent roles in stimulating interactions between industry and academia, but, these tools are selected based on their collective ability to attend to the functional problem of knowledge development by facilitating a change in actors' perspectives and addressing actor needs and problems. The selection criterion in both cases highlights that the overarching aim of the systemic instrument is to address the functional problems.

The findings show that systemic instruments operate through facilitating the aggregation of individual actions rather than through top down coordination by policy makers. This confirms the findings in Sabel and Zeitlin (2012; 2008) that alternative organisational forms are emerging in policy making that do not arise from top down coordination or spontaneously through an independent initiative but arise from problems that cannot be solved by established knowledge and the policy makers and private and public actors share uncertainty on how to resolve them.

It is evident from the case study findings that policy makers are not the only or most important decision makers in an innovation system as argued in Edquist (2011) and Smits and Kuhlmann (2002). It is confirmed that State agencies do play a role in the multi-actor problem solving arrangements, but not a dominant one. The findings provide empirical evidence that State agencies do not directly engage in problem solving activities but engage in facilitation activities that indirectly support the enabling environment. More specifically, State agencies have an indirect influence on the environment in which the innovating actors operate and not directly on the innovation processes. It is the collective contribution of the activities of the direct actors within the innovation system that deliver the structural change. In OG, the activities of the direct actors relate to efforts executed by the individual agri-food producers across the supply chain to switch to sustainable production practices. In FHI, the activities of the direct actors relate to the engagement of the individual partner in the interactive processes between the academic and industry partners on the topic of functional food R&D.

This study confirms the argument in Smits and Kuhlmann (2002) that a role required of State agencies is that of a mediator. As the operation of the instruments requires actor engagement to jointly explore the situation and implement actions to address it, the findings show that the State agencies in both case studies facilitate the aggregation of the individual actions of actors. In the case of securing institutions, OG uses compliance

mechanisms to link the activities of agri-food producers across the supply chain. In the case of stimulating interactions, FHI established a facilitator role. Acting as an agent between actors at various stages in the innovation process, both agencies can be depicted as an innovation intermediary as defined by Howells (2006). The compliance mechanisms used in OG are applicable to processes of validation and regulation undertaken by innovation intermediaries and the facilitator role in FHI is applicable to the processes of foresight and diagnostics undertaken by innovation intermediaries, discussed in Howells (2006).

The type of innovation intermediary identified in this study differs from that of an innovation broker examined in Study 2. The activities of a mediator centre on solely facilitating actors in the exploration of the problem and the alternative ways to address it and not with building relations between actors, although in the case of FHI this was a by-product of the mediation process. Whereas, the activities of an innovation broker centre on understanding the needs and problems of stakeholders, forming networks and managing the innovation process to build relations that change contexts to enable innovation (Fisher 2011).

The findings confirm that system, network and interactive processes within the innovation system influence the activities undertaken to achieve systemic instrument goals. System innovation relies on knowledge exchange and learning accessed through interactions at multi-levels of the innovation system as previously dicussed in the literature (Lundvall (2007); Fagerberg (2006); World Bank (2006); Smits and Kuhlmann (2004)). It is evident from the findings that the nature of the interactions between actors at various levels of the system evolves as learning occurs and the programmes develop. This supports the process view of an innovation system outlined in Klertx, Van Mierlo and Leeuwis (2012). In the case of FHI, it is evident that the nature of the interactions between actors changes over time. The work of Lester and Piore (2004), explains this further. FHI was initiated to resolve a defined problem within the Irish agri-food innovation system, the low levels of R&D in the area of functional foods. During the initial stages of the programme actors were cautious of each other and their communications were precise exchanges of information concerning the identified problem. This type of interactive process Lester and Piore (2004) categorise as analytical. Overtime, the dismantling of the organisational boundaries between the various industry and academia partners, undertaken by Enterprise Ireland, promoted the emergence of open-ended conversations with fluid information flows between actors. Therefore, as relations built between the partners, the interactive process became more interpretative the alternative type of interactive process distinguished in Lester and Piore (2004).

4.6.1 Contributions

The study concludes that the framework developed in Wieczorek and Hekkert (2012) provides a policy making tool that guides the diagnosis of systemic problems and the design of interventions to bring about system innovation. Overall, this study contributes new knowledge to the under exploited area of systemic instruments to add to this new field within innovation systems. The study contributes new empirical knowledge on how systemic instrument goals are implemented. It confirms that the policy tools chosen to implement systemic instrument goals reflect the nature of the problem, interactions with other tools and the contextual nature of the environment in which it is embedded, as suggested in Wieczorek, Hekkert and Smits (2012) and Wieczorek and Hekkert (2012). However, more applications of the framework are needed to draw conclusions on the theoretical role of policy tools in the implementation process.

In light of this study, the lack of guidance on the process to implement the structural solution within Wieczorek and Hekkert (2012) systemic policy framework is a weakness in the framework. This study provides new empirical knowledge on a role required of State agencies in facilitating the aggregation of individual actions of direct actors. This confirms the suggestion in Smits and Kuhlmann (2002) that a role required of State agencies is that of a mediator.

The study contributes new empirical understanding to the theory of innovation systems and innovation policy on using the innovation systems concept as an operational tool. In the context of policy support to improve the innovation performance, it is shown that systemic instruments can enrich our understanding of system, network and interactive processes that can improve the direction and speed of the innovation process (Lamprinopoulou et al. 2014; Wieczorek and Hekkert 2012; Klein Woolthuis, Lankhuizen and Gilsing 2005).

This study is the second known application of functionalistic approach to innovation system analysis within an agricultural domain (the first is Lamprinopoulou et al. 2014). The functionalistic approach employed in this study uses coupled functional-structural analysis to inform the design of instruments to achieve functional goals. The case study findings contribute new policy understanding on the implementation of two systemic instruments to create legitimacy around sustainable food production and develop knowledge in the area of functional foods in the Irish agri-food industry. To realise the market opportunities presented for the Irish agri-food industry, attention should be given to the performance of functions that support system wide change in the Irish agri-food industry.

4.7 Conclusions

This study investigated the design and implementation of systemic instrument goals to provide new empirical understanding on the Wieczorek and Hekkert (2012) framework as a practical guide for policy makers in the design and implementation of systemic instruments. The research examined two systemic instruments in the Irish agri-food sector: OG and FHI. The findings confirm that the policy tools used to achieve systemic instrument goals reflect the nature of the problem, interactions with other tools and the contextual environment in which they are embedded. Overall, the study provides empirical evidence on the framework as a policy approach to achieving system wide change in the Irish agri-food industry.

5 Conclusion

5.1 Introduction

This thesis set out to explore new thinking in innovation in the Irish dairy industry. A focus on innovation is paramount to delivering on the global agricultural challenges of food security and climate change and realising the production and market opportunities presented for the industry. Specifically, the thesis examines the aspects of innovation performance, innovation brokering and systemic instruments. In doing so, it explores dimensions of measuring, orchestrating and policy design towards innovation. In this final chapter, the findings of this thesis are discussed at three levels - the research findings from the three empirical studies, the broader reflections from the thesis and suggestions for future work.

5.2 Research Questions and Contributions

This thesis is divided into three separate studies: the relative innovation performance of dairy products on global markets (Study 1); the establishment of part time innovation brokers in a problem focused innovation system (Study 2) and; the design and implementation of systemic instruments as part of innovation policy (Study 3). The studies are linked by the homogenous theme of innovation and underpinned primarily by the innovation systems literature: Drawing on the philosophical approach of pragmatic realism, this thesis used a case study methodology in Study 2 and Study 3, to address the specific '*how*' nature of the research questions posed. In contrast, Study 1 answered a '*what*' question using an economic-based indicator of innovation to measure innovation performance.

In Study 1, the relative innovation performance of Irish dairy exports was measured using international trade data. In its first application to the agricultural sector, Kaplinksy and Readman's (2005) upgrading framework was used to identify the performance of Irish dairy products on global markets over the period 2000-2010. The specific research question studied was:

- *What is the relative innovation performance of Irish dairy products on global markets?*

Study 2 used the functions of an innovation broker to explore how part time innovation brokers fulfil their role and can be supported in their role. Using a variety of qualitative research methods (interviews, observations and document analysis), this study explored the establishment and activities of seven regional coordinators undertaking a part time innovation broker role in the national mastitis control programme, CellCheck. The specific research question studied was:

- *How might part time innovation brokers be supported in their role?*

Study 3, applied the systemic policy framework developed in Wieczorek and Hekkert (2012) to gain a better understanding of how policy makers can design and implement instruments that address system problems. Using the qualitative research methods of interviews and document analysis, this study explored the design and implementation of two systemic instruments in the Irish agri-food industry, Origin Green and Food for Health Ireland. The research question studied was:

- *How are systemic instruments implemented in the Irish agri-food industry?*

Based on these three distinct research questions, this thesis contributes new theoretical, empirical and policy related knowledge on innovation in the Irish agri-food industry in the following ways.

First, a particular methodology for measuring relative innovation performance – Kaplinsky and Readman (2005) upgrading framework – is applied to a new empirical setting, the Irish dairy industry. In addition, two limitations to using the framework are identified. First, the issue of profit switching transfer pricing which may distort trade data used to calculate innovation measures. Second, market support for EU agricultural produce may over-inflate the relative performance of EU produce on global markets. This contribution is contained in Study 1. Furthermore, linking the analysis of innovation performance in Study 1 and the case study research in Study 2 and Study 3, exemplifies the benefit to using more than one type of research method to enrich overall understanding of innovation in the Irish dairy industry.

Second, the research contributes new empirical evidence on the relative innovation performance of Irish dairy products on global markets. This contribution is contained in Study 1. Furthermore, the trade data analysis contributes somewhat to an understanding on the industrial organisation of the Irish dairy industry and its exports.

Third, in the context of policy support to improve the relative innovation performance of dairy products on global markets, it is shown that innovation brokering and systemic instruments are two mechanisms that enhance the innovative capacity of the industry and its stakeholders. Moreover, the analysis of the role of innovation brokers in Study 2 and the design and implementation of policy instruments that support system innovation in Study 3 enrich our understanding of system and network mechanisms that can improve the direction and speed of speed of the innovation process.

Fourth, in a contribution to the theory on innovation systems on operationalising innovation, it is shown that the construction of problem focused innovation systems, innovation brokers and systemic instruments can individually and collectively contribute to system innovation. This contribution is based on the findings in Study 2 and Study 3.

Fifth, in a contribution to the theoretical understanding of the orchestration of innovation, the relatively underexplored area of part-time innovation brokers is the context (Klerkx, Hall and Leeuwis 2009). Study 2 highlights that part time innovation brokering can comprise an actor or group of actors sourced from the *'innovation ecology*'. It is shown that part time innovation brokers can be supported in four ways: the promotion of experimentation and synergy of practices between the occupational role and innovation brokerage role; prior context analysis; the development of templates for activities; and lastly, the establishment of a peer networking group. This contribution is contained in Study 2.

Sixth, in a contribution to the soft systems view of an innovation system and the conceptualisation of an innovation system as a process (Klertx, Van Mierlo and Leeuwis 2012), Study 2 confirms that the activities of a part time innovation brokerage function are one way to coordinate the activities of diverse actors in a self-organising system. The study confirms that the intermediary role identified in CellCheck is that of innovation brokering which is a broader role than that of an information broker discussed in Burt (2008a; 2008b; 2007; 2004) and Lomas (2007) and a mediator identified in Study 3.

Seventh, the research contributes new empirical understanding on the design and implementation of systemic instruments to achieve system objectives. The research finds

that the policy tools used to achieve systemic instrument goals reflect the nature of the problem, interactions with other tools and the contextual environment in which they are embedded. This contribution is contained in Study 3. The findings provide further understanding on the implementation of systemic instruments. However, more empirical applications of the framework are needed to inform our understanding of the theoretical role of policy tools in the implementation of systemic instrument goals.

Eighth, in a contribution to the literature on new organisational regimes used in policy making (Sabel and Zeitlin 2012; 2008; Wieczorek and Hekkert 2012; Metcalfe and Ramlogan 2008), Study 3 provides evidence of the indirect role of State agencies in these system processes. The findings confirm the suggestion in Smits and Kuhlmann (2004) that a role required of State agencies is that of mediator. Overall, the thesis contributes new empirical understanding to the theory of innovation systems and innovation policy on using the innovation systems concept as an operational tool. It is shown that the construction of problem focused innovation systems and systemic instruments are created to address systemic failures. Furthermore, they can individually and/or collectively address such problems that are hampering innovation.

5.3 Implications for Policy

Growth in the Irish dairy industry is reliant on sustaining and improving competitiveness in its export markets. To achieve this, the industry is committed to achieving the Food Harvest 2020 targets of increasing the value of primary output, value added output, and exports. Innovation can support the achievement of these targets. Overall, the empirical findings of this thesis confirm that the Irish dairy industry is innovating. More specifically, dairy product manufacturers are engaging in product and process innovation and activities are being undertaken to improve the innovative capacity of the industry as a whole. However, there is potential to improve the innovation performance of the industry, by focusing on the direction and speed of the innovation processes (Lamprinopoulou et al. 2014; Hekkert et al. 2007; Klein Woolthuis, Lankhuizen and Gilsing 2005). This can be achieved by supporting the non-linear, systemic, uncertain nature of the innovation process (Smits and Kuhlmann 2004).

To support the interactive nature of innovation, policy makers should focus on building linkages between actors involved in the innovation process. The case study findings show an important role for indirect actors, such as State agencies, in stimulating interaction and collaboration between multi-disciplinary actors for innovation. For example, in the empirical context of Study 2, CellCheck and the empirical context of Food for Health Ireland (FHI) in Study 3, the agri-food stakeholders are in agreement on the problems hampering innovation in the industry and the need to collectively address these problems. However, in both cases there was a requirement for an innovation intermediary to stimulate the interactive process. Furthermore, based on the findings that some Irish dairy exporters are unable to innovate as fast as or faster than competitors (Study 1), programmes similar to FHI that support collaboration for innovation between industry partners and industry and academic environments are required to improve the time taken to deliver product and process innovation.

To support the systemic nature of innovation, policies should be informed by the socio-economic environment in which innovation takes place. The quality of the system relates to the structural and functional components that support innovation. The thesis research identifies problems in the structural components of the dairy industry such as interactions (between farm level service providers and farmers), institutions (standards around sustainable food production) and infrastructure (the processing capacity of the dairy product manufacturers). Furthermore, the research identified weaknesses in the functional activities of knowledge development (in the area of functional foods), and the creation of legitimacy (around sustainable food production). The findings from the case studies show that the innovation systems approach is a valuable tool to understanding and supporting

innovation. Using this approach, policy intervention is justified based on systems failure and not market failure. Policy interventions that target problems in the innovation can support system wide innovation. For example, the findings from Study 3 show systemic policy frameworks are a useful tool for policy makers to diagnose system failures and to inform the design of targeted instruments. To achieve a shift in production from commodity products to more value added products in the Irish dairy industry, it is vital to understand and address the innovation needs of the processing sector.

To support the uncertain nature of innovation, policy makers should promote and engage in experimentation among direct and indirect actors in the innovation process. It is clear from the analysis in Study 2 that the establishment of peer networking groups, which support mutual learning among peers, provides guidance on the uncertainty of the situation faced by the newly appointed innovation brokers. The findings in Study 1 highlight the scope for indirect actors such as State agencies to increase the participation of of direct actors such as dairy exporters in innovation. The provision of information through foresight documents and industry evaluation studies can encourage participation in the uncertain process. Furthermore, the constrained capacity experienced by the dairy exporters in terms of production has implications for the ability of the industry to respond to the rising global demand for dairy products. Government investment to support the expansion of production facilities would address this. The findings from this study emphasise the need to support private sector expansion in both processing and packaging facilities for two reasons. First, to enable dairy product manufacturers to increase their production to respond to rising market demand for dairy products. Second, to support a shift in the production of commodity products to more value added products which is a key strategic objective of the Irish dairy industry with the projected 50% increase in milk supplies in 2020.

5.4 Directions for Future Work

The research in this thesis focused on three aspects of innovation: measurement, orchestration and policy design. The specific literatures focused on were an economic based literature on measuring innovation using trade data and the innovation systems approach to understanding and supporting the innovation process. The thesis findings provide a number of future areas for research, which are briefly discussed in this section.

The limitations of the Kaplinsky and Readman (2005) framework to measuring the relative innovation performance of Irish dairy products on global markets provide an area for future work. The two categories of limitations of the framework were highlighted in Study 1. The first category relates to the framework assumptions of product homogeneity and market share gains outlined in Kaplinsky and Readman (2005).The second category relates to the application of the framework to an agricultural context and the potential for EU market supports and profit switching transfer pricing practices to bias the relative unit value and market share measures derived from trade data analysis. Trade data analysis cannot identify profit switching transfer pricing. This would require firm level data on intra-firm trade and transfer prices. In addition, the unknown level of innovative activity and, furthermore, the industrial organisation of the infant milk formula sector in Ireland, present an opportunity to undertake case study research on each of the Irish infant food manufacturers to supplement the upgrading analysis in this research. A multiple case study design could explore and compare the innovative activity across the three cases. This case study research could enrich the upgrading analysis in this study and also provide new insight to the industrial organisation of the infant food sector in Ireland.

Under the European Innovation Partnership programme, the conceptual framework of innovation brokering has recently been adopted by the European Commission to help set up operational groups through raising awareness and promoting participation among farm stakeholders. The seven innovation brokers in CellCheck, provide an empirical context to measure the impact of these innovation brokering activities on setting up an operational group. This future work would require an examination of the impact the innovation brokers have on stakeholder engagement in CellCheck activities such as farmer workshops and service provider training. The number of attendees could be identified by examining the records compiled by the regional coordinators and Animal Health Ireland.

One of the emerging themes from the thesis is the intermediary role required by indirect actors in the emerging forms of policy approaches used for system innovation such as problem focused innovation systems, experimental networks or systemic instruments. These approaches are neither bottom up nor top down but arise from problems that cannot

be solved by established knowledge and actors share uncertainty on how to resolve them. The case study findings in Study 3 confirm that a role for the State is that of an innovation intermediary. However, the need to further explore this role in other types of policy approaches for system innovation in other industries opens up a rich research agenda.

Appendices

Appendix A: Empirical Instruments Study 1

Figures and Tables relating to Chapter 2.

Table A.1 Percentage Change in Global Market Share for Ireland 2000-2010

	Market Share 2000	Market Share 2010	% Change in Market Share
Infant foods	0.287261	0.161582	-43.7508
Cheese	0.0269	0.029099	8.175523
Butter	0.120038	0.082883	-30.9529

Table A.2 List of countries (48) used to represent Asia in the upgrading analysis of infant foods

Afghanistan	Lebanon
Armenia	Malaysia
Azerbaijan	Maldives
Bahrain	Mongolia
Bangladesh	Nepal
Bhutan	Oman
Brunei	Pakistan
Myanmar	Palestine
Cambodia	Philippines
China	North Korea
Georgia	Qatar
Timor- Leste	Russian federation
India	Saudi Arabia
Indonesia	Singapore
Iran	Sri Lanka
Iraq	Syria
Israel	Tajikistan
Japan	Thailand
Jordan	Turkey
Kazakhstan	Turkmenistan
Republic of Korea	United Arab Emirates
Kuwait	Uzbekistan
Kyrgyzstan	Vietnam
Lao People Democratic Republic	Yemen

Note: Trade statistics for North Korea and Palestine are not available on the UN COMTRADE database.

Table A.3 The list of countries (26 EU Member States in 2011) representing Europe in the upgrading analysis of infant foods

Austria	Latvia
Belgium	Lithuania
Bulgaria	Luxembourg
Cyprus	Malta
Czech Republic	Netherlands
Denmark	Poland
Estonia	Portugal
Finland	Romania
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Ireland	UK
Italy	

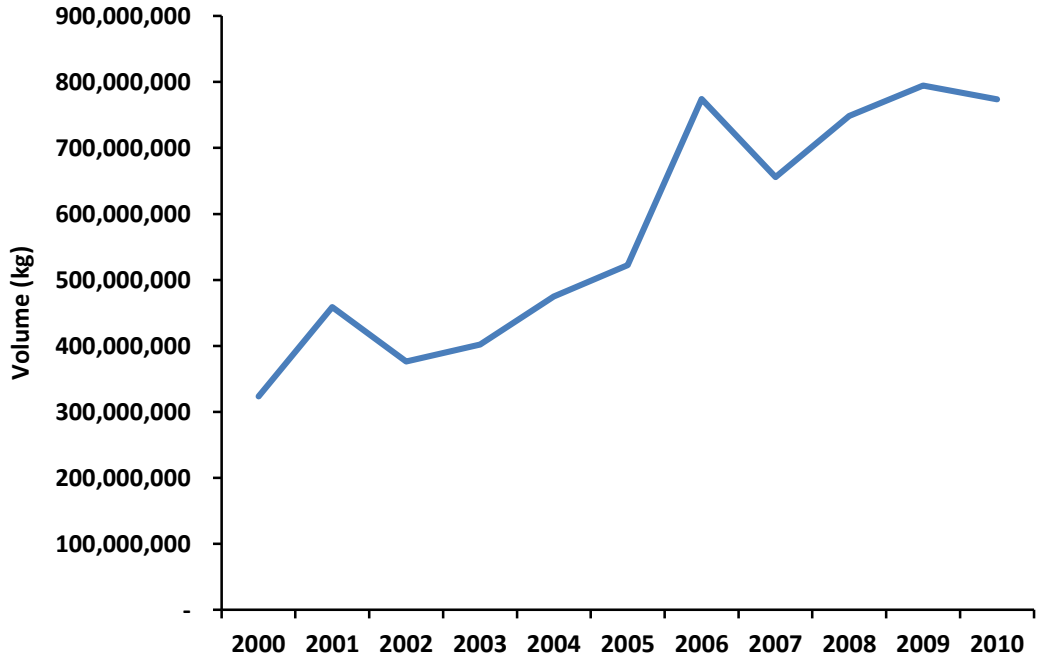

Figure A.1 Growth in the global market of infant foods (kgs) 2000-2010
Source: Author's calculations using COMTRADE data

Table A.4 The cheese product category definition and CN trade classification code

Product category	Detailed	CN trade classification code
Cream cheese	Fresh cheese 'unripened or uncured cheese' including whey cheese and curd of a fat content by weight greater than 40%	04061080
Cheese of a fat content by weight of > 40%.	Cheese of a fat content by weight of > 40%, n.e.s.	04069099
Mozzarella and cream cheese	Fresh cheese 'unripened or uncured cheese' including whey cheese and curd of a fat content by weight less than or equal to 40%	04061020
Type of grated or powdered cheese	Grated or powdered cheese (excluding glarus herb cheese, known as Schabziger)	04062090
Processed cheese (not grated or powdered) Emmentaler, Gruyère and Appenzell and Glarus herb cheese	Processed cheese, not grated or powdered in the manufacture of which is no cheeses other than Emmentaler, Gruyere and Appenzell have been used and which may contain, as an addition, Glarus herb cheese	04063010
Blue-veined cheese and other cheese containing veins	Blue-veined cheese and other cheese containing veins produced by 'Penicillium roqueforti' (excluding Roquefort and gorgonzola)	04064090
Gruyère and Sbrinz (excl. grated or powdered and those for processing)	Gruyere and Sbrinz (excluding grated or powdered and those for processing)	04069015
Jarlsberg (excl. grated or powdered and for processing)	Jarlsberg (excluding grated or powdered and for processing)	04069039
Fiore Sardo and Pecorino	Fiore Sardo and Pecorino of a fat content by weight less than or equal to 40% and a water content by weight of non-fatty matter of less than or equal to 47% (excluding grated or powdered and for processing)	04069063
Specific type of grated and powder cheese - glarus herb cheese	Glarus herb cheese, grated or powdered	04062010

Type of processed cheese, not grated or powdered (1)	Processed cheese, not grated or powdered, of a fat content by weight of less than 30% and of a fat content by weight in the dry matter of greater than 48% (excluding processed cheese mixtures made from Emmentaler, Gruyere	04063039
Cheddar (includes family of cheeses)	Cheddar (excluding grated or powdered and for processing)	04069021
Type of processed cheese, not grated or powdered (2)	Processed cheese not grated or powdered of a fat content by weight of less than or equal to 36% and of fat content by weight in the dry matter of less than 48% (excluding processed cheese mixtures made from Emmentaler and Gruyere)	04063031
Emmentaler (excl. grated or powdered and that for processing)	Emmentaler (excluding grated or powdered and that for processing)	04069013
Hard grated cheese (sold on the Greek market)	Cheese of a fat content by weight of less than or equal to 40% and a water content by weight of non-fatty matter of greater than 47% but less than or equal to 72% n.e.s	04069086
Similar to cheddar cheese but differentiated and considered a high value added product	Cheese of a fat content by weight of less than or equal to 40% and a water content by weight of non-fatty matter of greater than 52% but less than or equal to 62%	04069087
Product category includes Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey	Cantal, Cheshire, Wensleydale, Lancashire, Double Gloucester, Blarney, Colby and Monterey of a fat content by weight of non-fatty matter greater than 47% but less than or equal to 72%	04069081

Table A.5 The butter product category definition and CN trade classification code

Product category	Detailed	CN trade classification code
Type of dairy spread that is lower in fat than butter but no vegetable oil substitutes (1)	Dairy spreads of a fat content by weigh of greater than or equal to 60% but less than or equal to 75%	04052030
Butter oil (food ingredient)	Fats and oils derived from milk, dehydrated butter and ghee (excluding of a fat content, by weight of greater than or equal to 99.3% and a water content of weight of less than or equal 0.5% and natural butter, recombined butter and whey	04059090
Whey butter	Whey butter of a fat content by weight of greater than or equal to 80% but less than or equal to 85% (excluding dehydrated butter and ghee)	04051050
Recombined butter (not consumer food)	Recombined butter of a fat content by weight of greater than 80% but less than or equal to 85% (excluding dehydrated butter and ghee)	04051030
Type of dairy spread, lower in fat than butter but no vegetable oil substitutes	Dairy spreads of a fat content by weight of greater than or equal to 39% but less than 60%	04052010
Natural butter excluding immediate packaging	Natural butter of a fat content by weight of greater than or equal to 80% but less than or equal to 85% (excluding immediate packings of a new content of less than or equal to 1k.g. and dehydrated butter and ghee)	04051019
Type of dairy spread that is lower in fat than butter but no vegetable oil substitutes (2)	Dairy spreads of a fat content by weight of greater than 75% but less than 80%	04052090
Natural butter in immediate packing	Natural butter of a fat content by weight of greater than or equal to 80% but less than or equal to 85% in immediate packings of a net content of less than or equal to 1kg (excluding dehydrated butter and ghee)	04051011
Butter of a fat content, by weight, of > 85% but <= 95% (excl. dehydrated butter and ghee)	Butter of a fat content by weight of greater than 85% but less than or equal to 95% (excluding dehydrated butter and ghee)	04051090
Fats and oils derived from milk	Fats and oils derived from milk of a fat content by a weight of greater than or equal and of a water content by weight of less than or equal to 0.5%	04059010

Appendix B: Empirical Instruments Study 2

Observed Events

Interview Schedules

Observed Events

Table B.1 The observed events to confirm regional coordinators as innovation brokers

Date	**Activity**
20th June 2012	Stage 1 Service Provider training seminar
27th June 2012	CellCheck TWG meeting
27th June 2012	CellCheck focus group meeting
5th October 2012	Farmer workshop

Interview Schedules

Regional Coordinator Interview Guide 1

Title: How regional coordinators as first time innovation brokers seek to fulfil their role

Introduction:

The interviewer will introduce herself and discuss the purpose of the study with the interviewee by reading the information sheet before asking the interviewee to sign the consent form.

Preliminary questions:

The interviewer asks the interviewee questions about daily processor duties and interaction with stakeholders to gain insight into the decision by CellCheck to select regional coordinators from milk processing sector.

Conduct of interview/main questions: (45minutes; 15 minutes per question)

Becoming a regional coordinator

- Can you tell me about any engagements you had with CellCheck prior to being selected as a regional coordinator?
- Who approached you about becoming a regional coordinator?
- What was your motivation for undertaking the role?
- Can you show me on the map the region you are responsible for?
- Using your knowledge of the dairy sector and in particular mastitis control why do you think a coordinating role was orchestrated?
- What is CellCheck hoping to achieve with regional coordinator role?
- Why do you think milk processor representatives were selected as regional coordinators?
- Is based on processor enthusiasm for mastitis control?
- Why do you think you were chosen as coordinator for your region?
- How long have you worked in the region?
- What has been your affiliation with the dairy community in your region over the past number of years?
- How will the role affect your work duties with dairy processor?

Regional coordinator functions

- What is your understanding of the role of regional coordinator in CellCheck?
- What activities do you undertake to fulfil this role?

Demand articulation

- How are multi-stakeholder needs addressed?
- Currently 30% of farmers are not engaging with CellCheck do you know of any reasons why?
- Do you know of any issues stakeholders in your region have with CellCheck?

Network formation

- How do you select service providers to deliver farmer workshops?
- How do you identify the farmers to invite?
- When and how will you ask them to attend?
- Has your approach to selecting service providers changed? If so why?
- Can you describe your experience on doing this?
- How will you build partnerships between service providers?
- Did you have a role in training service providers? If so what was it?
- What obstacles do you perceive in undertaking the following functions
- Farmer workshops
- Building database
- Coordinating problem solving workshops

Innovation Process Management

- Thinking ahead what do you anticipate the long term role of regional coordinator in CellCheck?
- How will you encourage stakeholder engagement with CellCheck?

Is there anything else you wish to add?

Conclusion:

This entails a debriefing session, asking the participant if there is anything else they would like to add and if they are happy with the interview. The interviewer answers any questions in this section.

Thank interviewee for time and participation

Regional Coordinator Interview Guide 2

Title: Update with regional coordinators on how they seek to fulfil their role in CellCheck

Introduction:

The interviewer will thank interviewee for taking the phone call. The interviewer then discusses the purpose of the phone call is to learn of any changes that have occurred since previous interview that affects approach to fulfilling regional coordinator functions.

Conduct of interview/main questions: (45minutes; 15 minutes per question)

Now to begin, in light of the questions I asked during the first interview, I am interested in changes that have occurred since then that may positively or negatively.

Demand articulation

- What are your CellCheck duties as regional coordinator?
- Can you list the activities you have undertaken to date – workshops, seminars etc…?
- What activities are you obliged to fulfil in the future?
- How are you managing both processor and regional coordinator role?
- Is there any conflict there?
- As all farmers' requirements for mastitis control information differ, how do you go about identifying individual farmer needs?
- How do you encourage farmers to engage with CellCheck programme?
- What has worked to engage service providers with the programme in your region?
- Are you actively engaged in signing up new providers? If so, how?
- What in your experience has worked and hasn't worked?

Network formation

- How many workshops have you run to date?
- What has your experience been with organising farmer workshops?
- What is your role in delivering workshops?
- Who are farmer participants?
- Can you bring me through the process of organising a workshop starting with the selection of farmers, service providers, venue etc…?
- How do you select farmers for workshops?
- How do you select service providers to invite to deliver workshops?
- What in your experience has worked and hasn't worked?
- Would you do anything different at next workshop?

- At the time of the first interviews, uncertainty surrounded how workshops would be financed, has a decision been made?
- How did you begin to identify and select appropriate service providers?
- Have all service providers undergone CellCheck training?
- Is there a sufficient database of service provider volunteers within your region to draw on?
- Have you encountered any challenges with inviting farmers or service providers?
- Are there any on-going issues in relation to organising workshops?
- Have there been any challenges to service providers from different disciplines working together? If so how what are they and how are they addressed?
- Are there any challenges you can think of that have arisen or you foresee in the future in relation to the organisation and delivery of farmer workshop?

Innovation process management

- From your experience to date do you see any improvement in the uptake of such practices among regional farmers?
    - Milk recording
    - CMT
- What are these improvements?
- In your experience why has this improved/ not improved?
- In relation to farm guidelines, has there been any improvement in sales? Why?
- Are there any issues with service providers working together?
- An on-going issue for CellCheck is encouraging farmers to engage with the programme and in particular with trained service providers. In your experience how this could be improved in the future?

Supporting regional coordinator activities

- What advice if any has CellCheck team given in relation to organising workshops?
- How has CellCheck supported regional coordinators since undertaking the role?

Is there anything else you wish to add?

Conclusion: This entails a debriefing session, asking the participant if there is anything else they would like to add and if they are happy with the interview. The interviewer answers any questions in this section.

Thank interviewee for time and participation

Appendix C: Empirical Instruments Study 3

Documents

Interview Schedules

Documents

Table C.1 The documents studies for Origin Green case study

Title	Year	Author	Document type	Location
Participating Companies	2013	Bord Bia	Webpage	Origin Green website www.bordbia.ie/origingreen (last accessed 21st August 2013)
Pathways for Growth Building Ireland's Largest Indigenous Industry - Progress Update 4: June 2012-September 2013	2013	Shelman, Mary and Bord Bia	Report	Bord Bia website www.bordbia.ie/pathwaysforgrowth (last accessed 21st August 2013)
Origin Green Sustainability Charter	2012	Bord Bia	Guidelines on formulating plans	Origin Green website www.bordbia.ie/origingreen (last accessed 1st November 2013)
Mitigating GHG Emissions from Beef Production Systems: The Carbon Navigator	2012	Crosson, Paul	Conference paper	National Agri-Environment Conference
Carbon Audits for Irish Agriculture	2011	Teagasc Working Group on Greenhouse Gas Emissions	Report	Teagasc website http://www.teagasc.ie/publications/2011/1063/Briefing%20note%20on%20carbon%20audits%20FINAL3.pdf (last accessed 1st November 2013)

Table C.2 The documents studies for Food for Health Ireland case study

Title	Year	Author	Document type	Location
Carbery: The Case Study	2013	Head of R&D, Carbery Food Ingredients	Author's notes	Agri-Food Graduate Development Programme, '*Innovation in the Bio-economy*', University College Dublin (UCC)
Country Report: Ireland	2013	Henchion, Maeve. & Sorenson, D	Book chapter	Mapping Formal Networks and Identifying Their Role for Innovation in EU Food SMEs
Report of the Research Prioritisation Steering Group	2012	Research Prioritisation Project Steering Group	Industry report	Department of Jobs Enterprise and Innovation

Interview Schedules

Exploring the approach to secure the presence of institutions around sustainable food production

Preliminary questions:

The interviewer will ask the interviewee questions about the development and implementation of Origin Green programme

- How does OG measure, instruct and monitor sustainable production?
- How were they formulated?
- Who was involved?
- What is the role of government/government agencies in OG?
- What is the rationale for government involvement?
- What is the role of Bord Bia now and for in the future?
- How is farm and food company engagement promoted?
- Can you identify any challenges?
- How are they overcome?
    - By whom?
- Can you identify any challenges to the implementation?
- How were they overcome?
    - By whom?
- What is the level of interaction between members?
- Can you list programme achievements to date?
- What has been learnt?
- Did they influence change programme delivery? If so, how?

Conclusion:

This entails a debriefing session, asking the participant if there is anything else they would like to add and if they are happy with the interview. The interviewer can answer any questions in this section.

Exploring the approach to stimulate interactions between academic and industry partners in Food for Health Ireland

Preliminary questions:

The interviewer will ask the interviewee questions about the development and implementation of FHI

- Why use PPP to stimulate interaction between industry and academia
    - Why not,
        - Financial instruments – tax incentives/subsidies
        - Diffusion instruments – transfer schemes, innovation centres
        - Management instruments – management advice and support
- What influenced the decision?
- Who influenced the decision?
- Did partnerships already exist in the sector?
- What was the role of government in the initiating interactions?
- What was the rationale for government involvement?
- Can you tell me about the process to initiating interaction between the partners in FHI?
    - How did you do it?
    - Who was involved?
    - What were the obstacles?
    - How were they overcome?
    - Who was involved?
- Has FHI changed the level of interaction between the partners?
    - Between industry?
    - Between industry and academia?

Conclusion:

This entails a debriefing session, asking the participant if there is anything else they would like to add and if they are happy with the interview. The interviewer can answer any questions in this section.

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