Innovation in the UK fresh produce industry: sources, barriers and innovative capacity

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Abstract

The UK fresh produce industry faces a number of challenges, including new pests and diseases, foreign competition and the cost of and access to seasonal labour. 'Innovation' has been promoted to meet these challenges, but the sources of innovation, and what holds it back, have not been explored. This thesis aims to: 1) identify the sources of innovation in the fresh produce industry, 2) determine the barriers to innovation in the industry and 3) seek ways to improve the overall innovative capacity of the sector. It does so by using the Agricultural Innovation Systems (AIS) approach as an underpinning framework within a case study design. 32 industry practitioners, including growers, technologists, researchers and retailers took part in semi-structured interviews, which were analysed using Framework Analysis.

The study finds an increasingly consolidated and competitive industry, influenced heavily by retail groups and the need for constant innovation. It describes 'types' of innovation and their interlinked nature, as well as the inherent uncertainty around innovation and the difficulties in 'measuring' change. It finds that innovation often originates overseas and through experimentation or interaction with a given product or process. It describes both positive and negative communication in the industry and explores other blocking mechanisms to innovation including horizontal and vertical fragmentation, diverging innovation agendas and a "defensive" innovation culture.

It also identifies a number of enabling factors for change. Interactivity and network formation are recognised as vital components of the innovation system. However, considerable emphasis is placed on non-systemic factors, such as entrepreneurialism. These findings are combined with existing literature in a functional-structural analysis to offer recommendations to bolster innovative capacity in the industry.

The study makes several original contributions to knowledge, particularly with respect to the AIS approach: that innovation systems routinely extend beyond national borders, facilitated in part by another understudied issue – producer organisations – is an area for further research.

Abbreviations

ADAS	Agriculture Development and Advisory Service
AHDB	Agriculture and Horticulture Development Board
AIS	Agricultural Innovation Systems
AKIS	Agricultural Knowledge and Information Systems
AWD	Alternate wetting and drying
BBSRC	Biotechnology & Biological Sciences Research Council
BFP	Basic Farm Payments
BSREC	Biomedical and Scientific Research Ethics Committee (University of Warwick)
CAQDAS	Computer-assisted qualitative data analysis software
Defra	Department for Environment, Food and Rural Affairs
EU	European Union
FSR	Farm Systems Research
GDP	Gross domestic product
GPS	Global Positioning Systems
HAPI	Horticulture and Potato Initiative

HIP	Horticulture Innovation Partnership
IP	Intellectual property
IPs	Innovation platforms
KIBS	Knowledge-intesive Business Services
MAFF	Ministry of Agriculture, Fisheries & Food
MLP	Multi-level Perspective
NGO	Non-Government Organisation
NIAB	National Institute of Applied Biology
ONS	Office of National Statistics
P.O.	Producer organisation
R&D	Research and development
SME	Small and medium enterprise(s)
STF	Science and Technology Foresight
TT	Technology Transfer
WTO	World Trade Organisation
DTP	Doctoral Training Partnership

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Chapter 1: Introduction

1.1 Rationale

The UK fresh produce industry faces a number of challenges: exotic pests and diseases, input prices for oil, foreign competition, limitations in water abstraction, and restrictions on seasonal labour from overseas (National Horticultural Forum, 2011a). It must meet these challenges against a backdrop of climate change, a growing population and dwindling natural resources (BIS, 2013). Innovation through research and development (R&D) has been promoted to stem these problems and improve competitiveness in the fresh produce industry and wider agricultural sector (National Horticultural Forum, 2011a; see UK Government, 2010); however, the ways in which innovation emerges in the industry or is constrained – if at all – have received scant attention.

Over the last decades, the previously dominant agricultural R&D regime has evolved along increasingly demand-driven lines, challenging the 'post-War', linear model of agricultural extension and creating new problems and opportunities for innovation in agri-food systems (Klerkx, Aarts, & Leeuwis, 2010).

At the same time, UK agricultural productivity is also lower than that of many of its competitors (BIS, 2013). Some have suggested that the failure to 'translate' basic research into applied, farm-level solutions is contributing to lower-than-expected national agricultural performance (Pollock, 2012). However, it is increasingly recognised that innovation is not a linear process of transferring technological knowledge from scientists to end-users (Klerkx & Leeuwis, 2008b, p. 261).

In light of these interconnected issues, the Agriculture and Horticulture Development Board – the UK levy board responsible for commissioning research on behalf of levy payers – agreed to co-fund a project to explore these issues. As such, the questions framing this research project are:

1. What are the sources of innovation in the UK fresh produce industry?
2. What are the barriers to innovation in the fresh produce industry?
3. How can innovative capacity be enhanced?

1.2 Thesis structure

The thesis is organized as follows: in Chapter 2, a detailed literature review provides an overview of the UK fresh produce industry before summarising existing literature on innovation and the role of knowledge as it relates to innovation. Innovation in the *agricultural* context is then considered, followed by an explanation of the current theories and frameworks being used to explore this issue.

In Chapter 3, the methodological approach used to answer the research questions is explained, and justifications for its use given.

Chapter 4 outlines the findings of the research by exploring the key categories that have emerged during the analysis of the primary data collected during the project.

In Chapter 5, these findings are discussed in a critical manner drawing upon further literature to contextualise the findings outlined in the preceding chapter.

In the final chapter, conclusions and recommendations are made based on the analysis developed of the previous two chapters.

"Innovation is serendipity, so you don't know what people will make." – Tim Berners-Lee

Chapter 2: Literature review

2.1 Introduction

In this chapter, innovation is explored in its most general sense – starting with what defines “innovation” – before moving onto specific theories of change. Next, the complex relationship between knowledge, technology and innovation is investigated.

How innovation and knowledge have been studied in the agricultural context is then explored by introducing the fields of extension science and systems-orientated approaches. Finally, the systems theories that relate most directly to agriculture are explained – such as Agricultural Innovation Systems and Farm Systems Research – followed by a summary of what is understood about the ‘sources’ of innovation.

In the first instance, however, it is necessary to cover the focus of this project: the fresh produce industry and the evolution of industry support in terms of research.

2.2 The UK fresh produce industry

The fresh produce industry encompasses the production, processing and sale of fruits, vegetables and ornamental plants in the UK. The potato sector is also within the scope of this project, though it is not generally considered to be ‘horticulture’. “Produce” is a general term for fruits and vegetables that are sold “fresh” (or at least in a ‘harvest-like’ condition). Today, however, a good deal of produce goes on to be processed in some way, be it cut and frozen – cauliflower, for instance – or for use in prepared food. The UK horticultural sector includes more than 300 individual crops (Defra, 2013).

The industry was worth roughly £4 billion (Defra, 2017) in 2016[1] and employs 30,000 permanent workers, and over 55,000 seasonal workers[2] (primarily from Eastern and South-Eastern Europe) (Defra, 2013). In 2006, it was reported that 50% of horticultural holdings were under one hectare in size (Promar International, 2006); however, the same report argued that consolidation of the industry into larger units was increasing, a viewpoint shared by many participants in this project (see Section 4.2.1). The data corroborates this only to a certain extent, though accurate information on business consolidation is difficult to find (see Figure 1). A more relevant transformation in the industry is the new forms of organisation and vertical integration that have emerged in recent years (see below).

[1] This figure reflects output at market prices (including potatoes).
[2] This figure excludes the ornamental sector; the UK garden industry employs over 250,000 workers (Defra, 2013).

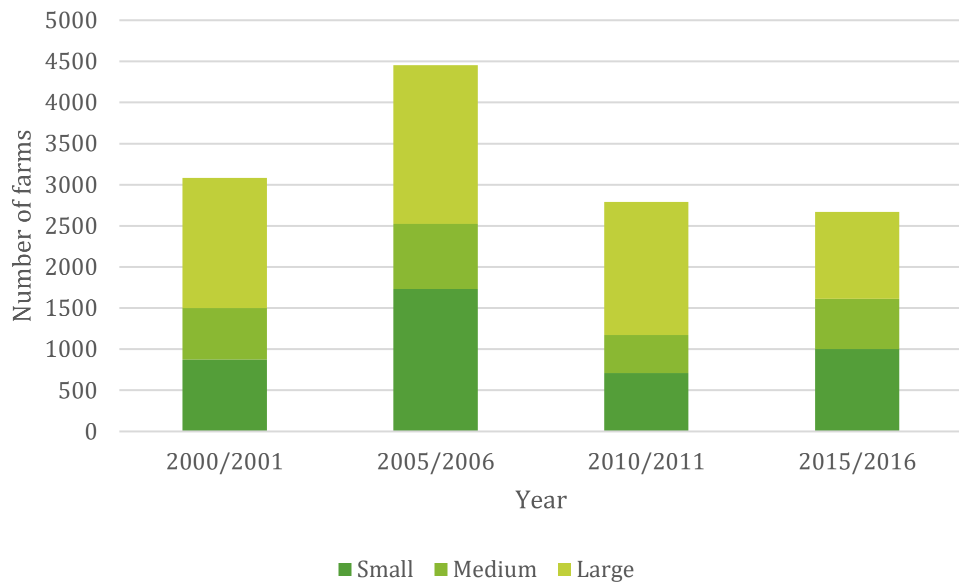

Figure 1 Number of horticultural farms in England by farm size over 5-year intervals (small = 1-2 full-time employees, medium = 2-3 full-time employees and large = 3+ full-time employees), compiled using Farm Business Survey data. The notable increase in the number of holdings in the 2005/2006 bracket is likely due to a methodological artefact in Defra statistics (see Appendix 2).

At the same time, the land under horticultural cultivation has roughly halved since the 1950s whilst production peaked in the mid-1970s and subsequently returned to post-War levels, implying an improvement in overall productivity (see Figure 2).

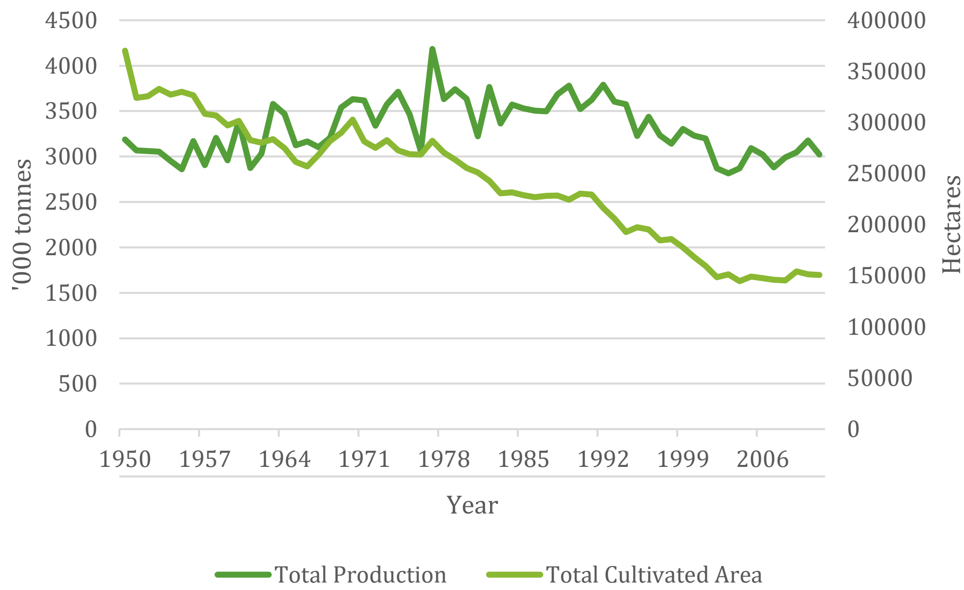

Figure 2 Total production of horticultural crops in '000 tonnes (excl. potatoes) against total cultivated area in ha. 1950 – 2011 in the UK, compiled using Defra Basic Horticultural Statistics.

Over the same period, the UK's reliance on imported horticultural goods has increased in contrast to its exports, which have remained fairly static (see Figure 3).

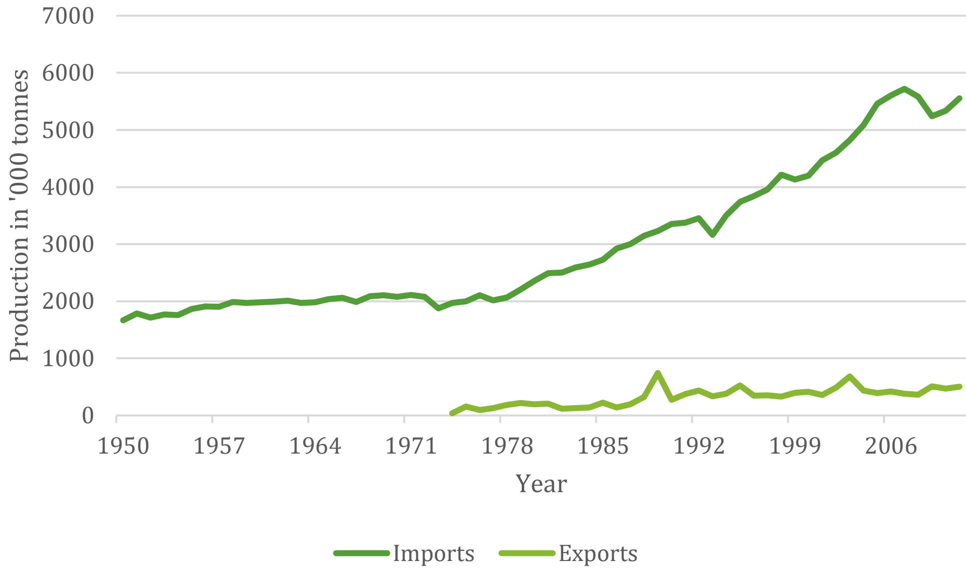

Figure 3 Total UK imports and exports of horticultural products in '000 tonnes (excl. potatoes) 1950 - 2011, compiled using Defra's Basic Horticultural Statistics

The vast majority of UK produce is sold through multiple retailers, with just four retail groups accounting for 74% of total sales (Promar International, 2006). The value of horticultural goods has also increased (see Figure 4), though, as shall be shown in Chapter 4, this has not necessarily meant an increase in return to growers.

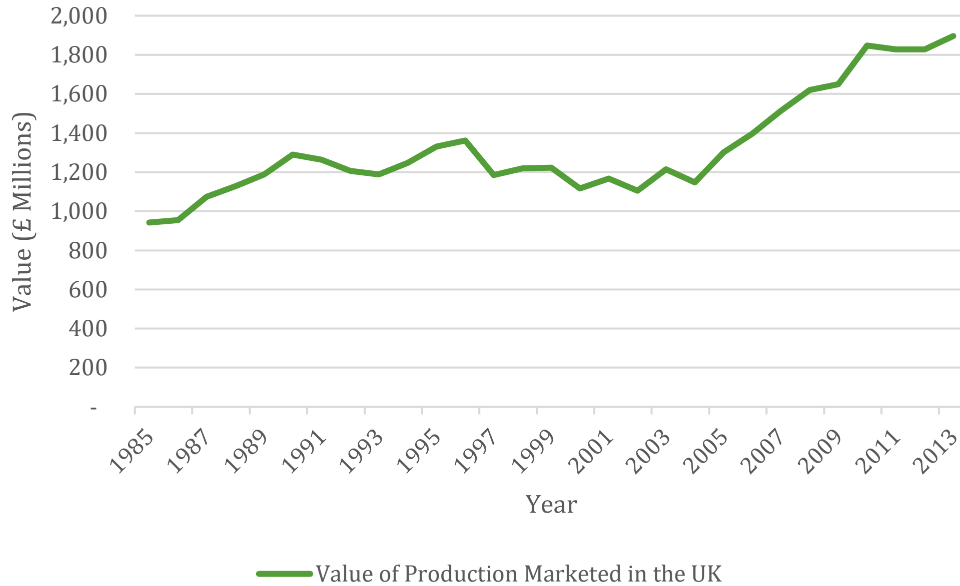

Figure 4 Value of horticultural products marketed in the UK in £ millions 1985 – 2013 (adjusted for inflation), compiled using Defra's Basic Horticultural Statistics

However, in recent years the market share controlled by the "Big Four" (Tesco, Morrisons, Sainsbury & Asda) has decreased, primarily due to competition by the "Discounters" (Lidl, Aldi), who, it is claimed, have also been responsible for growing produce markets (Searle, 2016). How this impacts upon innovation is discussed in Section 4.2.1.1.

Over the last several decades, one particular growing system has become especially popular with commercial fruit growers and specialist vegetable producers: polytunnels. These structures, properly called "Spanish tunnels", can be seen across the UK and are used to grow a variety of soft fruit, and, increasingly, tree fruit as well. Since their introduction by Haygrove in the late mid-1990s, polytunels have facilitated the doubling of turnover per hectare (to become the most valuable horticultural crop in the UK) and extended the growing season from six weeks to six months (Calleja, Ilbery, & Mills, 2012) Most interestingly, perhaps, these structures have 'equalised' regional differences between England and Scotland, minimising the problem of geography.

Despite the success of polytunnels in the soft fruit sector, a number of reports over the last ten years have made clear the challenges facing the industry as a whole (Brian Jamieson & Associates, 2008; National Horticultural Forum, 2011a; Promar International, 2006), as well as its evolving structural conditions and changing funding landscapes, which have undergone significant change. Today, the primary organisations responsible for horticultural R&D are the UK Research Councils (primarily the Biotechnology & Biological Sciences Research Council (BBSRC) for basic research) and the Agriculture and Horticulture Development Board (AHDB) for more near-market, applied research, which is funded by a statutory levy. Yet, this was not always the case.

2.2.1 New landscapes

Over the last few decades a major shift in the way the agricultural sector is supported has occurred, not only with regards to research – although that has been the area of most significant change – but also the kinds of financial support producers and others can expect from government. In the 1980s a reimagining of the role of the state took place, with stronger emphasis on market-based, demand-driven approaches to the provisions of goods (including agricultural research and extension services[3]) (Klerkx, de Grip, & Leeuwis, 2006).

In the UK, this manifested itself in the privatisation of the formerly public extension service, ADAS (Agriculture Development and Advisory Service), from the mid-1990s, which had until then been funded by the Ministry of Agriculture, Fisheries & Food (MAFF), and the emergence of a more competitive, tender-based research environment. Of England's 30 former dedicated agricultural research institutes (a potted history of which has been compiled by de Silva, 2012), only three remain (Hermans, Klerkx, & Roep, 2015). However, the creation of "agricultural knowledge markets" has resulted in new problems for those organisations 'producing' knowledge, and those organisations and individuals 'seeking' it (Klerkx & Leeuwis, 2008b); at the same time, the notion that innovation is a linear process in which knowledge is created by researchers to be passed out to industry has been repeatedly challenged (see Section 2.4.1).

It has also been suggested that gains made in the scientific realm have not had proportional impact in a practical sense (Pollock, 2012). Gone, claims Pollock (2012) is the "Golden Age" of scientific discovery and subsequent extension of new farming knowledge. Instead, a number of problems – including a shrinking applied research budgets and academic incentive structure which de-prioritises strategic needs – hampers efforts to adequately support the farming sector (Pollock, 2012).

[3] See Section 2.4.1 for more on extension services.

Given that new knowledge is a fundamental part of innovation (see below), these circumstances permeate all aspects of UK agricultural change.

2.3 Innovation

Innovation is a pervasive issue in both academic literature and policy debates (Malerba & Brusoni, 2007, p. 1), and arguably the "buzzword" of the 21st century (Phillips, Karwandy, Webb, & Ryan, 2013, p. 2). Why, then, is innovation important? And, in particular, why *now*?

Aside from the more obvious consequences of innovation – it is considered central to economic growth (Kline & Rosenberg, 2000, p. 7) and has the capacity to create jobs, or to destroy them (Edquist, 2005, p. 1) – the rate of innovation and obsolescence is today considered to be accelerating (N. Brown, Rappert, & Webster, 2016a). In a post-Recession world, innovation has taken on new dimensions as a means of economic recovery (Hausman & Johnston, 2014). For others, the importance of innovation – and specifically 'technology' – is its ability to *shape* society. Sociologists such as Castells (2010), for example, suggest that networks, underpinned by the development of information technologies in the 20th century, have become the dominant form of human organisational structure. These developments have led to practical knock-on effect in the social sciences; social network analysis (SNA), for instance, has been used to map knowledge flow in rural New Zealand (B. A. Wood et al., 2014) and technology adoption amongst farmers in Texas (Ramirez, 2013).

Whilst innovation is important, it is not easily understood. Our conception of what innovation *is* and *how* it 'comes into being' has evolved over time. The breadth of research on innovation has manifested itself in a multitude of handbooks on innovation, each with a different "twist" or focus (Malerba & Brusoni, 2007, p. 1).

Indeed, the many faces of innovation ensure it remains hard to define.

2.3.1 Defining innovation

It remains challenging to develop an agreed definition of innovation, as there is not a "… single, simple dimensionality to innovation" (Kline & Rosenberg, 2000, p. 7). Nelson & Winter (2000, p. 82) note that "innovation" is most commonly used as a portmanteau to cover the range of processes by which human technologies change over time. Some definitions account primarily for discreteness, with reference to "an" innovation. Other definitions interpret innovation as broader, technical or systemic change.

Joseph Schumpeter (1883 – 1950), known as the 'father of innovation', was the first to explore and define technical change in a systematic way. He enumerated five 'types' of innovation:

1. The introduction of a new good or quality of a good
2. A new method of production
3. The opening of a new market
4. The discovery of new resources or intermediates
5. A new organisational form

It is clear that Schumpeter's categorisation is comprehensive but does not give explicit reference to 'implementation', or the process of getting a new idea or product into use. According to Elenkov & Manev (2009) innovation is the "… process of generating and *implementing* new ideas" (author's emphasis) (see also Leeuwis, 2004, p. 12). Indeed, the spread and implementation of innovation is the focus of considerable academic attention: Roger's *Diffusion of Innovations* (first published 1962) Edquist & McKelvey's *Systems of Innovation* (Edquist & McKelvey, 2000) and, more recently, work on the 'Multi-level Perspective' (see Geels, 2005) each examine at various scales the transitions involved in socio-technical change.

Phillips *et al.* (2013, pp. 4-5) point out that even the assumption that innovation equates to "doing things better" is uncertain. New technologies often emerge in a relatively primitive condition that is not necessarily 'better' than the product or process it replaces. Instead, they argue, adoption – the decision to use a particular product or process – is determined by whether the users of an innovation *perceive* some benefit in using it.

Likewise, the ambiguity of the word "new" is controversial. How 'new' does something have to be to qualify as *innovative*? Given the root of the word – the Latin *novus,* meaning 'new' – it is unsurprising that some feel 'newness' needs to be invoked in any comprehensive definition of innovation. At the same time, it is not always possible to discern where one innovation begins and another ends; take, for instance, an example of agricultural innovation as explained by Feder (1993, p. 216):

"… high-yielding varieties (HYVs) in particular, are in fact a package of interrelated technologies (for example, fertilizer, herbicides, and chemicals). Accordingly, one major focus in the literature in recent years has been the investigation of the decision-making process characterizing choice of the optimal combinations of the components of a technological package over time."

The co-dependency of innovation on other innovation – and the need for aligning social factors – requires us to think beyond innovation in the singular sense (i.e. "an" innovation) and to innovation as a process of larger technical change, such as that found in the *innovation systems* tradition:

"... innovation is neither research nor science and technology, but rather the application of knowledge (of all types) in production to achieve desired social or economic outcomes. This knowledge might be acquired through learning, research or experience, but until applied it can not be considered innovation." (A. Hall, Mytelka, & Oyeyinka, 2006, p. 13)

In some sense innovation pulls other words into its 'orbit': the term "technology" is commonly used to refer to a discrete product or process – and is almost synonymous with "innovation". Yet it is often conflated with innovations of a highly visible sort – airplanes, vehicles, computers – to the potential neglect of 'invisible', but equally important, incremental innovation. As Kline & Rosenberg (2000, p. 282) observe, such minor, cumulative modifications can have large impacts over a long enough timeframe.

Figure 5 An 'all-encompassing' vision of innovation, demonstrating the need for change across multiple domains (Klerkx, van Mierlo, & Leeuwis, 2012b)

As for "knowledge", this is either a necessary component of innovation or, as Edquist & McKelvey (2000 pp. xi) would have it, innovations are in fact part of a larger process in the development of knowledge of economic relevance. Indeed, the importance of knowledge for modern economies is exemplified by the rise of the "knowledge economy", in which the production of knowledge has proliferated (Powell & Snellman, 2004) – this is no less true in the agricultural domain, where the "technology transfer" (TT) approach to development has given way to systems theories of change that promote knowledge exchange and social learning (see Section 2.4.2).

Klerkx *et al*. (2012b, p. 458) suggest that innovation is a co-evolutionary *process* – a combination of "... technological, social, economic and institutional change". As such, the exchange of *technical* knowledge is not the only prerequisite for innovation, a position that permits the possibility of diverse sources of innovation, as well as a variety of barriers to innovation stemming from the complex interplay of these factors. For the purposes of this thesis, the definition above is considered the most appropriate.

However, beyond demonstrating the complexity of innovation, there is little to be gained from lingering too long on its definition; some authors dispense with the need to define the term at all, or simply use "technology" as a portmanteau for the same (Frenken, 2006), suggesting that there is an instinctual understanding of 'what we're talking about' when we talk about "innovation".

2.3.2 Understanding innovation

Innovation is today the focus of a number of different academic disciplines, and, as our understanding of the subject has expanded, so too has the number of lenses through which innovation can be examined. What began with attempts to model economic growth now seeks to account for how a wide range of factors – including policy, institutional arrangements, learning and conflict – determine innovation outcomes.

A brief history of the development of approaches to understanding innovation is given, before exploring these trends in an agricultural context.

2.3.2.1 Exogenous and endogenous growth

As Phillips *et al.* (2013, p. 14) note, the most extensive literature on innovation, growth and development is found within the neoclassical economics tradition and its "extensions".

Classical economists, such as Adam Smith (1776) and Jean-Baptiste Say (1803) touched upon innovation and technical change. In *A Treatise on Political Economy: or The Production, Distribution, and Consumption of Wealth* (first published in 1803) Say noted that increases in wealth originate:

"From the increased command acquired by human intelligence over productive powers… a power has been rendered available for human purposes, that had not been known before, or not directed to any human object; as in the instance of wind, water and steam-engines: or one before known and available is directed with superior skill and effect, as in the case of every improvement in mechanism, whereby human or animal power is assisted or expanded. The merit of the merchant, who contrives, by good management, to make the same capital suffice for an extended business, is precisely analogous to that of the engineer, who simplifies machinery, or renders it more productive." (Say, 2001, p. 163)

In the middle of the twentieth century, economists concerned with macroeconomic trends were developing a model for long-run economic growth. It was found that neoclassical models developed during the 1950s predicted an eventual 'steady state' of zero *per capita* growth (Barro & Sala-i-Martin, 2004, p. 61). In this scenario, the amount of new capital produced is only enough to keep pace with natural population growth and to replace the capital lost due to depreciation over time (known as *diminishing returns*) (Acemoglu, 2008). However, industrial output has continued to outpace population growth since the Industrial Revolution; *technological change* was the presumptive missing factor (Grossman & Helpman, 1994). As Grossman & Helpman (1994, p. 26) note:

"Surely the earth's (relatively) fixed stocks of land, natural resources, and raw labor would impart diminishing returns to accumulated inputs if those inputs were forever combined to produce a fixed set of goods by unchanging methods."

Neoclassical growth theorists recognised this modeling deficiency and "patched it up" by including technological progress as an *exogenous* factor in such models (i.e. there is some rate of technological change affecting the model, but the determinants of that rate exist outside of the model). The same was true for population growth, which was likewise included as an exogenous factor in variations of the neoclassical Solow-Swan model (Barro & Sala-i-Martin, 2004, p. 18).

The importance of the Solow-Swan model lies in what it tells us (and does not tell us) about long-run growth; economic models that do not account for improvements in productivity enter a steady-state in which output per head equals the cost of maintaining capital per head as the population grows. If we include both population growth and productivity growth as some exogenous rate of change, it results in long-run economic growth. However, this only indicates that having some positive rate of productivity improvement leads to long-term growth and not what factors govern such growth or the rate at which it changes over time (Barro & Sala-i-Martin, 2004, p. 18). The 'how' of innovation is thus relegated to a "black box" in neoclassical economics. As Rosenberg notes in *Exploring the Black Box*, economics "… was content to treat – or perhaps a more appropriate operational verb would be "to dismiss" – technological change purely as an exogenous variable, one that had economic consequences but no visible economic antecedents" (Rosenberg, 1994, p. 9).

This was an important development: the determinants of technological change cannot be 'boiled down' to a fixed, exogenous rate. It has been suggested that differences in rates of technological change explain the differences in economic performance between countries (Barro & Sala-i-Martin, 2004); this must be true, or every country – every region – would be endowed with the same technological capabilities and level of productivity.

It would appear that technological change is dependent upon internal factors in the economy of concern. Berliner (1976) notes that the innovative performance of one economic system over another is no measure of the quality of that economic system if we ignore the historical and cultural traditions of the society built upon it; a society that has long fostered scientific enquiry, technological prowess and entrepreneurial spirit would be expected to be more innovative than a society not exhibiting these traits. This is supported by Freeman, who notes that the performance of the Japanese and later South Korean economies from the 1980s relative to the economies of post-Soviet eastern Europe, despite comparable investments in R&D, yielded vastly different results (Freeman, 2000, p. 47- 48).

Clearly, more complex factors were at work. Such observations, and a renewed interest in economic growth since the 1980s, have led to the development of *endogenous* theories of growth, in which the determinants of growth were explicit in the models themselves (though, it should be noted, these remain 'neoclassical' in their basic assumptions about the world). Put simply, factors within the economy could determine the rates of technical change or even population growth over time. For example as GDP increases, fertility rates tend to decline and long-term growth can be seen as predominantly dependent on government action via taxation, protection of intellectual property and provision of infrastructure (to name only a few mechanisms by which an economy can be shaped) (Barro & Sala-i-Martin, 2004, p. 18).

At the same time, neoclassical models of growth contain another contested assumption: *perfect rationality*. Firms and people cannot predict with much accuracy the impact of their endeavours, whether launching a new product or investing in one, meaning that even if they are acting in their own rational self interest, they are not doing so from a position of complete certainty (Rosenberg, 1994, p. 5). As such, organisations and individuals are described as having *bounded rationality* (i.e. they can only know so much about the consequences of their actions and about the economic world they inhabit). That innovation carries with it inherent uncertainty is a cornerstone of agricultural innovation systems thinking (Section 2.4.2).

Nelson & Winter (Nelson & Winter, 2000) speak of the need for an economic theory that saw technology as undergoing continuous evolution.

2.3.4 Evolutionary economics and path dependence

In a withering assault on the neoclassical imagining of innovation and economic growth, Clark & Juma (2013 preface) claim that:

"... the world described in most economic models is not the world in which we live... it is a world of determinate solutions to pre-specified problems, where economic phenomena (i.e. those to which property rights can be assigned) can be separated from everything else and where there is no uncertainty... [ours] is a world of ***complexity****,* ***relative ignorance*** *and* ***irrelatedness*** [author's emphasis]*, where our present state has an evolutionary history... it is an 'open system', non-linear, indeterminate world..."*

As such, the field of *evolutionary economics* takes inspiration from Darwinian natural selection where innovation is mediated by similar pressures as found in biological systems. From this point of view, technologies are both artefacts of technological evolution and units of analysis, "... the design of which takes place by trial-and-error learning" (Frenken, 2006, p. 3). The evolutionary character of such change is dubbed "path dependence", which, simply put, implies that past technological developments define the possibilities of future technological change (Garud & Karnoe, 2013; Rosenberg, 1994). An example of path dependence is the rise and dominance of industrial agriculture, epitomised by high use of mechanisation and agricultural inputs such as pesticides and fertilizer. Of course, from an economic point of view this makes sense: increasing scale reduces the cost of input per unit output. However, the post-War model of agricultural subsidy and support was, in several key ways, designed to support industrial agriculture (see Clapp, 2012, p. 11). In this way, the dominance of industrial agriculture is maintained, an example of what proponents of the Multi-level Perspective would describe as an incumbent "regime" (Ingram, 2015).

The application of evolutionary economic theory to the task of understanding how economies change over time continues unabated (see Malerba & Brusoni, 2007) and the importance of evolutionary economics to the study of innovation has manifested itself in a number of ways: models of economic growth must now account for how businesses imbed organisational learning over time (Dosi, 2007) or the interplay between economy, society and natural environment in debates on sustainability (see van Griethuysen, 2002). However, this also represents the gradual recognition of factors beyond "simple" rates of growth or productivity. That R&D policy or approach towards intellectual property, for instance, are recognised as having a bearing on real-world innovation, and that such processes provide a degree of path dependence to technological development, shows that there is more than one 'level' to the study of innovation.

2.3.5 Theories of innovation, change and transition

A number of 'general' theories of innovation seek to explain how innovation works *in practice*, treating it not as some fixed rate of change in an economic model or mysterious process inside a "black box" but as a process that must be understood in its own right. Each introduces new language and concepts – sometimes from other fields – to emphasise competing or complementary factors governing innovation.

2.3.5.1 Diffusion of Innovations

Everett Rogers' *Diffusion of Innovations* (1962), now in its fifth edition, is considered a seminal work in this regard. It introduced what have become common terms in innovation studies, such as *first* and *early adopters*, and *laggards*. Concerned primarily with how a given innovation – defined in this case as an idea, practice or object that is perceived as new to an individual or another unit of adoption – spreads through an economy, Rogers suggests there are several factors that determine the rate of adoption and success of a given innovation:

1. Characteristics of the *innovation itself*, such as its comparative advantage over similar products, its complexity, and compatibility with existing systems determine the likelihood that it is implemented by a unit of adoption
2. A *communication channel* is the means by which different individuals or other units of adoption spread the knowledge associated with a given innovation, its functioning shaped by degree of homophily – the 'sameness' of its participants – found within the channel
3. A third element of the diffusion process is *time*; the "innovation-decision process" occurs over time and involves, in the first instance, learning of the existence of an innovation to the eventual adoption or rejection of that innovation
4. The final factor taken into consideration is the *social system* in which an innovation is to be embedded. A social system is defined here as the set of interrelated units that are engaged in solving common problems, be it a collection of peasant farmers or group of doctors in

a hospital. A social system includes the 'rules and norms' people adhere to and re-produce, as well as the opinions of 'change agents' or 'champions', who carry an innovation along.

Certain aspects of the *diffusion* scholarship have been challenged and revised over time. For example, how an innovation might be "re-invented" for a specific context could not originally be accounted for in the early iterations of the theory (Rogers, 1983, p. 17). However, the work of Rogers and others remains concerned with causality: how, and why, do innovations spread over time? It relegates the origins of innovation to, firstly, the recognition of a problem, and, secondly, the development of a solution to that problem through formal, purposive R&D. Interestingly, many of Rogers' observations are built on the work of rural sociologists investigating change in an agricultural context in the United States during the 1940s and '50s. Yet contemporary theories of agricultural innovation place far more emphasis on the ability of farmers to contribute to innovation themselves and the often haphazard, experimental and informal way that new practices in farming originate (Chambers, Pacey, & Thrupp, 1993). In a similar way, innovation is reduced to a linear, market-driven process in which there are no "feedbacks" or possibilities for failure (the *linear model* of innovation):

Research → Development → Production → Marketing

In terms of measurement, *diffusion* scholars tend to rely on the rates and proportion of adoption of a given innovation over time and amongst end-users. An "S-shaped" curve is commonly used to model this diffusion, the y-axis depicting the prevalence of the innovation and the x-axis representing time and the five categories of adopting unit: *innovators*, *early adopters*, *early majority*, *late majority* and *laggards*. The steepness of the adoption curve indicates the speed at which a given innovation spreads.

This remains an influential way of thinking about innovation, but since its initial publication, other theories of innovation have begun to expose the dynamics of diffusion in other ways.

2.3.5.2 (National) Systems of Innovation

Coupled with the growing influence of evolutionary economic perspectives on economic theory at the time (discussed in Section 2.3.4), the *Systems of Innovation* approach that emerged in the 1990s emphasises the importance of complex, endogenous determinants of innovation, drawing on the work of scholars now readily associated with innovation: Carlsson (2002), Rosenberg (1994), Lundvall (2007), Nelson and Winter (2000).

Stemming from the recognition that innovation must involve some kind of learning process, and given that learning is an inherently interactive endeavour, *Systems of Innovation* scholars pay particular attention to interaction between the innovating parties in a given system. As Edquist & McKelvey (2000) observe, it is interactivity that "paves the way for a systemic approach". Indeed, writing with regards to what he perceived of as the 'agricultural system', Spedding (1988, p. 15) notes that for the word "system" to mean anything, it must be something that can be contrasted with a non-system. For Spedding, a system can be explained through the phrase: "behavior as a whole in response to stimuli of any part". In this respect, it is how the actors in an innovation system interact, and the institutional regime in which they interact that determines the generation, spread and rate of adoption of innovations. The interplay between the public and private sectors in a specific country, for instance, has a bearing on innovation; these factors themselves being rooted in the history, language and national culture of that nation (2000, p. 73). Of course, the increasingly globalised nature of the economy – and innovation – is recognised, though this remains concerned with flows of knowledge at and between different geographic scales (see Gertler & Levitte, 2006).

The term *National Innovation Systems* has, as Lundvall (2007, p. 95- 97) explains, become widely used both by policy makers and scholars (though not necessarily 'correctly'). It also forms the basis for other, more specific analytical frameworks, such as Agricultural Innovation Systems (discussed in the next section). The National Innovation Systems approach often involves quantification of certain national indicators such as R&D expenditure and rates of economic growth to assess the functioning of the system.

What *innovations systems* research has in common is summarised by Edquist & McKelvey (2000) in nine parts:

1. *The centrality of innovations and learning processes*: innovation is given to be the product of various learning processes. This includes 'learning by doing', whereby an individual gains knowledge about a product or process and determines ways in which it might be improved, and searching for new economic knowledge through R&D.

Such a focus is retained in agricultural innovation systems theories (AKIS, AIS, see below).

2. *Holism and interdisciplinarity*: systems approaches, in general, can be characterised by the desire to capture the wide array of factors that determine the nature of innovation. In order to achieve this, it is unlikely that one discipline will be sufficient illuminate such a range of factors.
3. *Historical perspective*: given the lag between the technical invention, transformation and economic application of an innovation, a historical perspective is the 'natural' frame to explore the emergence and spread that innovation.
4. *The difference between systems and non-optimality*: in the *Systems of Innovation* approach, the differences between different systems, be they national, regional or sectoral, are the subject of focus and, as such, should not be ignored. A comparative approach is therefore necessary in some way, but with the rejection of any notion of optimality or a "perfectly functioning system" in evolutionary theory, comparisons should be made with systems that actually exist.
5. *Emphasis on interdependence and non-linearity*: it has long been recognised that firms do not innovate in isolation, but rather take part in the process of combining knowledge from multiple sources (such as universities and other research institutes), a recognition that has driven the development of the *Systems of Innovation* approach. As explained above, it is the interactions between constituent parts of the innovation system that is the subject of focus for practitioners; the emphasis on the complex nature of these relationships is both an advantage and challenge of the approach.

Such relationships are held to be reciprocal, exhibiting feedback mechanisms and "loops", and, evidently, cannot be thought of as 'linear' or unilateral.

6. *Encompasses products technologies and organisational innovations*: mainstream economic theory tended to treat innovation as processes decreasing employment or other inputs per unit of output. However, product innovation – be it the personal computer or a pharmaceutical – is clearly also a source of important technological innovation. Likewise, organisational innovation has clear impacts and, importantly, can be necessary to embed new technologies, in concordance with those broad definitions of innovation outlined in Section 2.3.1.
7. *Centrality of institutions*: not only relevant to innovation, but a "striking" component of the innovation systems approach is the emphasis on 'institutions'. Conceived of differently by various authors, institutions might be thought of as normative structures that support, stimulate or even, sometimes, hinder the process of innovation and its diffusion. For instance, government policy, law or funding for research constitute an institutional regime.
8. *Conceptual ambiguity*: the very scope of innovation systems research presents conceptual obstacles (exacerbated, one might argue, by the inclusion of various scientific disciplines) stemming from the vagueness of certain terms. Even the term "national innovation system" is troublesome, the limits of which are either given to be unclear or even unknowable. Edquist (2000, p. 29) himself notes that there is no clear "… demarcation between a system and its

surrounding context”. The limits of the fresh produce “system” are defined in Section 3.2.1.

9. *“Conceptual frameworks” rather than formal theories*: innovations systems approaches remain rather loose and informal relative to “hard”, immutable theories. As frameworks, they provide avenues for further research, as opposed to the more rigid, predictive capacity of formalised theory; this philosophy is maintained in the present project.

Given the complexity of the factors at work, the dominant model of innovation, or ‘linear model’, has fallen out of favour with those investigating innovation. Kline & Rosenberg (2000, p. 16) suggest the idea that innovation is initiated by research is wrong “most of the time”, leading us to question the directionality of the linear model. Innovation does not occur “in a bubble”. It is perhaps worth noting that the physical and biological sciences *do* tend to move through “recognizable major stages” (Kline & Rosenberg, 2000, p. 23) and may represent industries where this is *true* most of the time. Innovations also generate benefits “far from the industries in which they originate” (Kline & Rosenberg, 2000, p. 280). Indeed, predicting the impacts of innovation can be troublesome (see Section 4.3.4).

A further ‘place-based’ *innovation systems* framework relates to “clustering”, or the process by which firms and not-for-profit organisations co-locate in a specific geographic region *inside* a national innovation system. Increasingly, city regions are seen as hotbeds of innovation and economic growth (Phillips et al., 2013, p. 30), but precisely why this should be the case – and why businesses and other organisations should co-locate rather than spread evenly across an economy of concern – is subject to debate (whether government policy can or should mediate this process is also an area of concern). Common to most explanations of clustering is the benefit a firm can derive from proximity to a skilled labour force, supporting industries and knowledge "spillovers", in which relevant information passes quickly between different organisations (see Phillips et al., 2013, p. 32). Clusters can also form around certain natural resources. In the case of farming, this can provide a company with place-specific production and marketing opportunities (protected designation of origin schemes for wine, for instance, serve to enhance this situation) (see Musso & Francioni, 2015).

2.3.5.3 Transitions and the Multi-level Perspective

In certain contemporary theories of innovation, a systemic focus is maintained but it is the 'transition' of these systems that is the focus of attention. *System Innovation* (as opposed to Systems *of* Innovation and Innovation Systems) is concerned with how entire systems transition between states (often towards more sustainable configurations). Here, a system is conceived of as a broad societal function: the food system or transport system, for example. In need of more than what Elzen *et al.* (Elzen, Geels, & Green, 2004, p. 1) dub "incremental", end-of-pipe innovations, these systems require "… new technological artefacts, new markets, user practices, regulations, infrastructures and cultural meanings".

Stemming from the recognition that the many competing theories seek to explain different aspects of systems innovations, Frank Geels (see Geels,

2004) proposes using the integrative framework of the multi-level perspective (MLP) to understand these transitions. Originating from a combination of sociology of technology and evolutionary economics, MLP theorists suggest that there are three heuristic levels to be considered when investigating systems innovations; the *socio-technical regime*, or body of practices, rules and ways of defining problems that are embedded in the institutions of a given system: the *socio-technical landscape*, in which technological 'trajectories' are embedded, corresponds to the material infrastructure of society, such as the placement of cities and factories. A *landscape* is stable, rigid, even, containing "slow-changing" factors like cultural values and political opinion, but is not without shocks, such as war or natural disaster; *technological niches* are the third component of the MLP, which in contrast to the 'incremental' innovation of the *regime*, generate radical innovation fostered in 'safe', protected spaces (niches). Selection criteria, to use Darwinian terminology, operate differently in niches when compared to elsewhere. For example, the jet engine and the laser were both developed through military research programmes, sheltered from 'the market' at large. As such, niches provide spaces for the learning processes, such as learning by doing and social network formation that are associated with new innovations (Hippel, 1988; see Rosenberg, 1994) – a subject that will be returned to in Section 4.5.2. Although the regime, landscape and niches provide a degree of structuration, which confers stability on the system, it also makes it difficult for novelties to 'break through'; existing regimes are 'entrenched', reinforced by the institutions, cultures and economics of the current modality. Others have pointed out the need for a 'guiding' vision to orientate an innovation system (Hekkert, Suurs, Negro, Kuhlmann, & Smits, 2007).

Importantly, the MLP adds a crucial element to the investigation of systemic failure of innovation systems – the notion of *directionality* (Weber & Rohracher, 2012). In this vein, "direction" implies that systems can move towards (and away from) certain, existing technological regimes.

As Weber & Rohracher (Weber & Rohracher, 2012) point out, *innovation systems* theories remain dominant in policy debates – promoting the maximisation of innovative capacity in firms and other organisations – but are "less suited for dealing with the strategic challenges of transforming systems of innovation, production and consumption, and thus with long-term challenges such as climate change or resource depletion". Instead, they promote the MLP and associated *Strategic Niche Management* and *Transition Management*. These refer to the creation of protected spaces for technological niches, and, for example, understanding how innovation niches interact with the current regime (see Ingram, 2015), and the broader aim of managing such transitions respectively.

2.4 Innovation in agriculture

The study of innovation in agriculture has a long lineage. Indeed, many 'general' theories of innovation have made use of case studies that focus on innovation in farming (such as Roger's *Diffusion of Innovations*, discussed above). A focus on formal research and extension dominates the early academic work in the field, and though this has never been entirely supplanted, the idea of formal research being at the heart of agricultural innovation has been challenged from the 1980s onwards by observations about the sources of innovation in farming. The *innovations systems* approach would go on to offer a new way to envision technological change in agriculture, and it is the evolution of these ideas that is the subject of the remainder of this chapter.

It can be supposed that the privileged place agriculture holds with regards to academic, governmental and organisational attention can be in part explained by importance of food and nutrition. Few governments, if any, adopt a purely free market approach to food production and provision, which has manifested itself in state-sponsored research and in other tools to improve agricultural productivity. In the post-War period, governments in most countries took a strongly interventionist, incentivised approach to agriculture (Clapp, 2012, p. 11). In the UK this took the form of guaranteed prices and quotas for milk and grain, with agricultural research being supported through various government agencies (such as MAFF and later Defra). A focus on yield led to an industrialised, high-input form of agriculture in the developed world – in turn, and through 'one-sided' trade negotiation led in the main by the United States, this model of agriculture became the *de facto* blueprint of Western state policy (see Clapp, 2012).

A more 'hands-off' approach to agriculture has replaced this model since the 1980s in many places, with those connected to the industry now required to commission research directly or support agricultural research through levy payments. It is not coincidental that this new arrangement began to appear as the dominance of the 'neo-liberal' model of economic growth, with its emphasis on trade liberalisation, gained supremacy in policy circles. Food has become increasingly commoditized and transnational food corporations now hold considerable power across the food supply chain and with respect to governance, practices and norms (Clapp, 2012; see also Clapp & Fuchs, 2009).

Case studies *from* and researchers' experience *in* the developing world – where state-funded agricultural research has tended to dominate over private – has also been instrumental in the development of more general theories of agricultural innovation and farming-focussed research methodologies (Darnhofer, Gibbon, & Dedieu, 2012). For example, both Röling's *Extension Science* (1988) and Chambers's *Farmer First* (1993), each hugely influential, made use of considerable groundwork in developing countries (Kebebe, Duncan, Klerkx, de Boer, & Oosting, 2015; see also Schut, Klerkx, Rodenburg, Kayeke, Hinnou, Raboanarielina, et al., 2014a; Spielman, Ekboir, & Davis, 2009). Agriculture tends to form a greater percentage of national employment and GDP in developing nations when compared to their wealthier counterparts (Clapp, 2012, p. 7) and are the focus of much more humanitarian and developmental attention. In some sense, developing world agriculture has become a test-bed for understanding or at least building theory, notably by those involved in research at international research institutes (see M. B. Douthwaite, 2002). Interestingly, the goals of agricultural research today are the source of conflict; one 'battleground' of this "Contested Agronomy" being for whose benefit agricultural research is carried out, a distinct line drawn between the needs of different groups of farmers, often, but not exclusively, along the global divide of 'north' and 'south' (Sumberg & Thompson, 2012). Certain suites of technology, and in particular genetic modification of food crops, have come to symbolise this divide.

Charting the broad trends in agricultural development, the work of Pardey and Alston, and other agricultural economists, has demonstrated the changing face of global agricultural research spending and, importantly, its real-world impact in terms of productivity (Alston & Pardey, 2014; Alston, Babcock, & Pardey, 2010; Pardey, Beintema, Dehmer, & Wood, 2006). More importantly, perhaps, is evidence that investment in agricultural research does not result in diminishing returns; there are no so-called 'low-hanging fruits' in agricultural research that mean subsequent endeavours are less impactful (Alston, Pardey, & Smith, 1999). However, such work has uncovered a declining rate of public investment in agricultural research in favour of private (Alston et al., 1999) as well as a growing divide in the level of investment in agricultural research between the developed world, the large developing economies of Brazil, China and India, and 'the rest' (of the world) (Pardey et al., 2006).

Innovation is not only a consideration at the macroeconomic level, however. A number of microeconomic studies, primarily focused on the individual or farm as a unit of analysis, are common, notably within the ever-evolving field of extension science (see next section).

2.4.1 Extension science

Extension science is an academic field concerned primarily with the effective management and communication of agricultural science. The practice of *extension* itself has many definitions (see Leeuwis, 2004, p. 24-25), and these range from the passive:

"… assistance to farmers to help them to identify and analyse their production problems and to be aware of the opportunities for improvement" (Adams, 1982 pp. xi)

To the more interventionist:

"A professional communication intervention deployed by an institution to induce change in voluntary behaviours with a presumed public or collective utility" (Röling, 1988, p. 49)

One can trace the roots of this tradition back to rural, out-of-college lectures linked to Oxford and Cambridge universities in the mid-1850s, and, perhaps further still if one includes one of several agricultural societies created for this function in the early 19^{th} century (to say nothing of ancient Egyptian hieroglyphics depicting discussions related to crop management or ancient Chinese woodblock "handbooks" used to disseminate agricultural knowledge) (see G. E. Jones & Garforth, 1997). During the British Agricultural Revolution the country saw a distinct growth in output of agricultural patents and books (well documented by Ang, Banerjee, & Madsen, 2013), and by the time of the Irish Potato Famine (1845 - 49), calls were being made for the Royal Agricultural Improvement Society of Ireland to send lecturers to Ireland to assist in disseminating information about crop-rotations and other root vegetables (G. E. Jones & Garforth, 1997).

It was in France that the first wholly state-funded extension service appeared in 1879, though such organisations would remain, in France and elsewhere, small-scale and limited in scope and contact with farmers until the middle of 20th century (G. E. Jones & Garforth, 1997). The post-War era of agricultural research and extension in the global North, tasked with eradicating food shortages, was considered a "golden age" of extension in which research and extension practices operated in harmony (see Pollock, 2012). The successes of this model, and its failures, have had a notable impact on modern theories of innovation in agriculture, notably the AIS tradition (A. Hall, 2007). On the one hand, the ever-changing social and natural environment that farmers face, and, on the other, a scaling back or even wholesale privatisation – as in England – of national extension services since the late 1980s/90s has resulted in new challenges for extension practitioners (Klerkx & Leeuwis, 2008a). These factors, and their relationship to innovation, form an important part of this thesis; the loss of public extension services in England is still being felt, several decades after the event (see Section 4.8).

However, some of the tasks associated with public extension services have been taken over by private business and non-governmental organisations (NGOs) (Leeuwis, 2004, p. 17) Matching the supply and demand of agricultural research in this new arrangement is known to have been problematic (Klerkx & Leeuwis, 2008b), and is, at least in part, the impetus for this project. With regards to innovation processes, Klerkx & Leeuwis (2008b, p. 261- 262) isolate five key challenges faced by agricultural entrepreneurs, comparable to small- and medium-sized companies (SMEs) in other industries, that have emerged in the wake of the decision to privatise formerly public extension service:

1. *Adequately articulating demands*: SMEs experience difficulties in defining their needs to knowledge-producing organisations, and the “cognitive distance” between the different actors involved – farmers and academics, say – may cause co-ordination and learning problems
2. *Developing adequate resources and competencies*: whilst public extension services were supply driven – “technology push” – and largely prescriptive, the current situation requires entrepreneurial initiative, such as developing competencies around knowledge acquisition and learning to bolster absorptive capacity[4] (see Chauvet, 2003). This is made difficult for SMEs as they often lack the time and funds required to invest in acquiring new knowledge or technology. Indeed, this proves a major barrier to innovation (Section 5.2.1.1).
3. *Dealing with market failure*: the market for agricultural knowledge is increasingly heterogeneous, leading to information/knowledge asymmetry between actors, as well as difficulty identifying services, or what Bougrain & Haudeville (2002) call an “information gap”, something that is returned to in Chapter 5.
4. *Financing agricultural R&D and services and knowledge provision*: agricultural entrepreneurs now have to mobilise funds to take advantage of the kinds of knowledge that were previously provided for free; likewise, knowledge providers, such as research institutes and universities, now have to compete for contracts with clients in a market that is increasingly “pluriform” and served by non-traditional

[4] Cohen & Levinthal (1990, p. 129) define absorptive capacity as: “the ability to value new external information, to assimilate it and to apply it to commercial ends”.

providers of agricultural R&D and knowledge. In this procurement environment, uncertainty increases costs for everyone involved.

5. *Overcoming systems failures*: due to strategic interests, weakened institutional linkages and inherent differences between types of actor in the agricultural system, “knowledge infrastructures” have become more closed (see Section 4.9).

The challenges noted above consist of both factors at the institutional level (such as market failure) and at the personal or firm level (developing in-house resources). Some of these issues are present in the fresh produce industry (see Discussion).

Today, extension science remains an important discipline for understanding agricultural innovation (especially in those places that maintain state-supported agricultural research and extension). It is impossible to list the range of problems to which extension science has been applied: the term “extension science”, for instance, registers 4,700,000 results using Google Scholar (as of November 2016). However, a number of unifying themes and methodologies can be discerned: the adoption of new innovations by a target group is the most common area of concern, including the identification of disabling and enabling factors governing this process, primarily at the personal level (income and education, for example) (see Ghadim & Pannell, 1999; Jacobson, Sieving, Jones, & Van Doorn, 2003; Maheshwari & Plunkett, 2015; Mercer, 2004; Sajeev & Gangadharappa, 2011): the exploration and/or facilitation of knowledge sharing amongst target groups is another (P. Brown, Hart, Small, & de Oca Munguia, 2016b;

Materia, Giarè, & Klerkx, 2014; Pangborn, Woodford, & Nuthall, 2011; B. A. Wood et al., 2014).

Yet, as times have changed, so has agricultural research and extension, at both the conceptual and practical levels. The *Diffusion of Innovations* tradition enjoyed strong popularity amongst extension practitioners, resulting in what Röling describes as a preoccupation with 'progressive farmers', or those deemed to be at the forefront of innovation (Röling, 1988, p. 4). Röling (1985), describes a subsequent preoccupation with *knowledge systems*, building the base for later theories of Agricultural Knowledge and Innovation Systems (AKIS & AIS, discussed below). Some have sought to change how we conceive of extension practice entirely. Cees Leeuwis (2004), building on the work of influential scholar Anne van den Ban, calls for the re-invention of agricultural extension; noting that as the challenges for farming change, so too must the organisations that support them. In a widely cited volume that reinforces Wageningen University's place as a world-leader in the subject (indeed, the Netherlands remains a key source of new ideas for the UK fresh produce industry, explained in more detail in Section 4.5.1) Leeuwis' *Communication for Rural Innovation* (2004, pp. 3-10) outlines, in the first instance, some of the ways in which agriculture has been challenged and what that entails:

- *Food security and intensification*: despite the fact that a range of social factors can negatively influence food security – bad governance, detrimental trade relations etc. – food production remains a key means of alleviating food insecurity as global demand increases. Given increasing limitations on land use, competition for water and the failure of Green Revolution technologies[5] in sub-optimal conditions, agricultural options that do not rely on the intensive use of prescribed external inputs such as fertiliser, pesticide and high-yielding crop varieties may be needed. Indeed, Feder (1993) shows that the agri-climatic environment is the most significant factor determining the spread of agricultural technology (see also Fujisawa, Kobayashi, Johnston, & New, 2015), suggesting the relevance or *fit* of a new idea to a given setting is vital, a theme returned to in Section 4.8.4. However, underpinning this need for flexibility will be technical and social innovation.

- *Poverty alleviation and income generation*: improvement in agricultural development stands to benefit poorer people directly – greater income through farming – or indirectly – since agricultural development is regarded as a condition for non-agricultural economic growth. Of course, resource-poor farmers also struggle to acquire external inputs associated with conventional farming elsewhere, reinforcing the need for alternative forms of intensification.
- *Sustainability*: the detrimental effects of agriculture, such as soil degradation, habitat destruction and water pollution (to name only a few) have led to calls for a more sustainable agriculture. As such, this means agriculture should make better use of resources. However, as several authors have pointed out (see Röling & Wagemakers, 1998)

[5] Scholars such as Prabhu Pingali (2012) are less dismissive of Green Revolution technologies, highlighting the role they have played in increasing global food production (as well as congruent poverty reduction).

sustainability cannot be looked at in a purely biophysical way, but with regards to how humans shape ecological systems.

- *Globalisation and market liberalisation*: the world economy, for a variety of reasons, has become increasingly orientated around the 'free market', supported by World Trade Organisation (WTO) rules and advances in communications technology. In turn, this provides both constraints and opportunities for agriculture.
- *Knowledge intensity and commoditisation*: many of the challenges named here can only be met by developing and harnessing more sophisticated and appropriate knowledge – as the importance of the so-called "knowledge economy" grows, a firm's competitive advantage is dictated less by relative advantages such as labour costs and increasingly by the timely use of knowledge. At the same time, knowledge, with the privatisation of extension services and competition for research funding, has become a marketable product for which a price must be paid. A result of this is a reduction in the free exchange of knowledge across the sector.

Leeuwis goes on to describe how agricultural extension must evolve in the future, branding this new imagining "communication for rural innovation":

- *Collective issues*: in the past, extension theory has focussed on supporting individual farm management and promoting "farm-level innovations". However, today many of the challenges faced by the agricultural sector 'transcend' the individual farm household, requiring new forms of co-ordinated action and support, among farmers as well as other stakeholders. It is a mistake, Leeuwis reminds us, to view innovation as being individual in nature; innovation often requires an alignment of various social and technical factors to happen. Such a view requires us to look at things like diverging interests and different perspectives (examples from this research are discussed in Section 4.2), rather than, as in the past, focussing on the narrower process of adoption at farm level.

- *Co-designing innovation, not dissemination*: a tendency amongst extension organisations to promote, as Leeuwis describes them, poorly-adapted and pre-defined innovations that were developed by researchers with little regard for farmers' priorities or problems has been well documented and challenged (Chambers et al., 1993; Röling, 1988; see Van Veldhuizen, Waters-Bayer, & De Zeeuw, 1997). Given the challenges listed above, "pre-defined" innovations seem less appropriate for the complex solutions required in modern agriculture. Indeed, local contexts often demand that innovation is adapted (or "re-designed"), encompassing new processes of learning and negotiation. Instead, greater emphasis needs to be placed on *innovation design* and adaptation, whilst recognizing that it is only through stakeholder interaction that complex and suitable innovation can occur (collective innovation). In this vision, extension organisations facilitate innovation processes by, for instance, translating the views and concerns of the farming community and external researchers, rather than disseminating discrete innovations.
- *Matching the social and technical dimensions of innovation*: innovation, even if technical in nature, often requires change at the social level to work in particular settings. A recent example – of many possible examples – can be found in the case of alternate wetting and

drying (AWD) irrigation in rice production, which, although shown to reduce water consumption without harming yields, has seen limited adoption amongst rice farmers; in Nepal, a number of social factors such as current water-extraction practices and similar, locally-developed techniques, were found to have prevented the spread of AWD (Howell, Shrestha, & Dodd, 2015). Leeuwis (2004, p. 13) notes that innovation has a lot to do with creating support networks and negotiating new arrangements between stakeholders.

- *Catering for diverse interests*: it has been assumed that agriculture moves in one particular direction, exemplified by the language of *Diffusion* (see page 24). For instance, "first adopter" and "laggard" suggest everyone involved in farming should be moving in the same, knowable direction. Of course, even farms that operate under similar conditions can develop along different, but economically viable, paths. We see diverse business strategies and aspirations in farming. In earlier work, Leeuwis (1989) found that so-called "laggard" farmers adopted a similar number of innovations when compared with those that followed extension advice more closely. As such, extension organisations can expect to cater for diversity (as demanding as this may be in practice).
- *Brokerage*: when funded by government agencies or donors, extension organisations often find themselves in a "broker position", having to mediate different interests. In the first instance, national or regional governments might be interested in fostering a certain kind of development (strengthening exports for example) and organisations tasked with realising this endeavour must demonstrate that they are doing a good job. At the same time, those

> same organisations must maintain their credibility in the eyes of their immediate customers who might have entirely different priorities. Building such credibility is the subject of Section 5.5.

As the field of extension science itself adapts to the changing conditions of extension regimes in the real world, other frameworks have emerged to explain the complex processes of change in the agricultural world that help understand, and contextualise, the role of such endeavours in fostering agricultural development.

2.4.2 Systems-orientated approaches to innovation in agriculture

Innovation systems theories have found a home in agricultural innovation studies. The emergence of systems approaches in agricultural innovation stem from a recognition that problems in agriculture are increasingly understood to be "... complex, uncertain and operate at multiple levels, from the field to the global supply chain, and involve social, economic, institutional and technological change" (Turner, Klerkx, White, Payne, & Everett-Hincks, 2015b, p. 1). As Hall (A. Hall, 2007, p. 5) notes:

"In 1998 a small group of researchers in India started to experiment with the innovation system concept as an analytical aid to help understand why otherwise promising research and development projects failed to bring about desired social and economic changes."

Today, a family of related (but different) approaches, including AKIS, FSR and AIS, continue to make use of 'systems thinking'. Such a view represents "current" thinking on innovation in agricultural systems, indicating the profound challenges to, and replacement of, the *research-extension-farmer* model of agricultural change that, like the agrarian sciences associated with it, can be considered *positivist* and *reductionist* in outlook[6] (Koutsouris, 2012).

Klerkx *et al*. (2012b) chart the development of these theories in agriculture, noting that although systems enquiry in an agricultural context has matured in relative isolation from other systems traditions, there has been a degree of cross-fertilisation. Several broad stages of thinking can be discerned:

1. *Adoption and diffusion theories*: these are characterised by the Technology Transfer (TT) paradigm initiated by Rogers (Rogers, 1983) and include a strong emphasis on social systems, but treat institutions and policy as external factors influencing rates of adoption.
2. *Farm Systems Research (FSR)*: this perspective emerged in response to perceived inadequacies of the more linear approaches to agricultural innovation. FSR aims to take a holistic account of agricultural change by "... capturing the interactions between farms and their natural, social and economic context" (Darnhofer et al., 2012, p. 3).
3. *Agricultural Knowledge and Information Systems (AKIS)*: this tradition also grew out of dissatisfaction with the linear model of

[6] That being said, Klerkx *et al.* (2012b) position the *Diffusion* tradition within the systems lineage given its focus on social networks and mass media (social systems).

Technology Transfer but traces its lineage to extension science. It focuses on the organisations interactions between different actors as they produce, adapt, transmit and store knowledge. In its earliest incarnations (see Stenvang et al., 2013) AKIS adopted a "hard systems" view; the system in question has a 'solid' boundary and common purpose, which exists independent of the observer and, by extension, can be "engineered" towards an unambiguous goal. However, AKIS has come to be epitomised by "softer systems" thinking in which it is accepted that the boundaries of a given system will be understood differently by different people within it (an issue returned to in 3.1.2). As framework for understanding, AKIS has been particularly influential; the European Commission, for example, has framed recent policy debates around a conceptualisation of the European agricultural innovation system as an AKIS (EU SCAR, 2012).

4. *Agricultural Innovation Systems (AIS):* growing in tandem but separate from AKIS, is AIS, which was instead influenced by *National Systems of Innovation* thinking. It differs from AKIS in its scope, broadening the horizon to include all relevant organisations in agricultural innovation (and not only research and extension systems) (Hermans et al., 2015, p. 38). Innovation in this context is given to be the result of multiple interactions between farming systems, supply chains, policy environments, and economic and social systems (Klerkx et al., 2012b). As Klerkx *et al*. (2012b) explain: "... the main achievement of the AIS approach thus appears to be that it has further broadened the scope of analysts and interventionists on the complex interactions between a multitude of players and sub-

> systems that characterize innovation". Not only is this the most "recent" in the family of systems-orientated approaches to agricultural innovation (Klerkx et al., 2012b), it also represents the most pertinent approach to tackling the kinds of complex problems that are the concern of this project (Schut, Klerkx, Rodenburg, Kayeke, Hinnou, Raboanarielina, et al., 2014a, p. 1).

Given its focus on issues similar to those framing this thesis, it is worth exploring the AIS approach in more detail; diagnostic AIS approaches have been used to identify the barriers to innovation in various settings (see Polzin, Flotow, & Klerkx, 2016; Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a) and even in parts of the UK (Lamprinopoulou et al., 2012).

Taking an AIS perspective, Klerkx *et al*. (2012b) describe different views regarding what can "enable" and "disable" innovation, though it should be acknowledged that the idea of optimising innovation systems hinges upon one's precise conceptualisation of the agricultural innovation system and its components. An *infrastructuralist* view of the AIS sees its purpose as being to *support* agricultural innovation, and its success is thus determined by the extent to which it enhances or hinders agricultural innovation in a rather static manner; a *process* view of AIS sees the innovation system as a self-organising system of networks, that come and go in the pursuit of novelty. An inherently dynamic process with clear influences from the Multi-level Perspective, the configuration of the value chain in such systems is seen as moving ever towards an alternative to the 'incumbent regime', perhaps even threatening it entirely (A. Hall & Clark, 2009). As such, this view of the innovation system borders on the idea of *system innovation* – the transformation of a system to a new, innovative configuration (see Elzen et al., 2004; Geels, 2005). In turn, a well-functioning AIS is, according to this perspective, determined by the extent to which niches can be supported and system transition encouraged (see Section 2.3.5.3); lastly, the *functionalist* view of innovation like that described by Hekkert (2007) sees the innovation system as providing several important functions. Klerkx *et al*. (2012b) note the similarities between the evolutionary perspective on evolution here: a biological system cannot function without each of its components – organs – fulfilling some function or other.

By mapping such functions and the interactions between them, one can pinpoint areas of 'systemic failure' to inform policy (see Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a for example). As such, it is possible to assess the functioning of this system against its supposed 'functions' in a systematic way (see Hekkert et al., 2007; Kebebe et al., 2015; Suurs, Hekkert, Kieboom, & Smits, 2009; Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a). The seven functions of innovation systems are as follows:

1. *Entrepreneurial activities* use the potential of new knowledge, networks and markets to create value (see Klerkx & Leeuwis, 2008b). Such activities can also include lobbying and attempts to 'restructure' institutional environments.
2. *Knowledge development* is considered a fundamental prerequisite to innovation (Kebebe et al., 2015, p. 70) and the ability to create new knowledge a vital component of effective AIS. Creation of new knowledge is not restricted to formal research establishment; farmers and agro-businesses can also be a source of new knowledge.

3. *Knowledge diffusion* through networks is particularly important to further develop and adapt knowledge and innovations, and to "scale them up" (by garnering support in terms of favourable policy and market conditions) and "out" (by increasing the number of users). In other words, to enhance the "co-evolution of social, technological, institutional and market changes" (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a, p. 3). An emphasis on the importance of innovation 'platforms' and networks where this interactive learning can occur is common in AIS literature (Kilelu, Klerkx, & Leeuwis, 2013; Klerkx et al., 2013; Schut, Klerkx, & Sartas, 2015).
4. *Guidance of the search* concerns the creation of a "vision" for the innovation system with which to orientate other system functions (such as entrepreneurial activity and knowledge development). Turner *et al.* (2015a) stress that 'innovation agendas' can be used to this effect. Mylan *et al.* (Mylan, Geels, Gee, & McMeekin, 2014, p. 22) also note that shared meanings, expectations and a clear vision for the future can stimulate innovation by reducing uncertainty and providing a sense of direction to innovation processes.
5. *Market formation* concerns the development of markets for novel products or existing products made in new ways, which can prove challenging due to resistance from the consumer and/or 'incumbent players'.
6. *Resource mobilisation* involves the management of the human and financial resources to undertake activities within the AIS; this includes funding for research and subsidies for certain technologies for example, as well as to attract appropriate expertise in "innovation trajectories".

7. *Creation of legitimacy* is necessary to counteract resistance to change inherent in existing systems of production, trade and consumption.

Structures are the actors, institutions, interactions and infrastructure that determines the operation of these seven functions:

1. *Actors* are individuals, firms and other organisations, that tend to be delineated by their economic activities (i.e. NGO, business, government).
2. *Institutions* range from 'soft' (habits and routines) to 'hard' (rules, norms and strategies) factors shaping the activity of actors.
3. *Interactions* are the dynamic relations between different actors.
4. *Infrastructure* refers to either 1) physical infrastructure (such as roads or existing technology, 2) knowledge infrastructure, such as research and extension facilities or 3) financial infrastructure such as grants, subsidies and financial programmes.

A plethora of 'types' of system failure exist between these functions and structures (see Klein Woolthuis, Lankhuizen, & Gilsing, 2005). Weber & Rohracher (2012) provide an outline of these failures, which fall into the broader categories of *market*, *structural* and *transformational* failure. However, as Woolthius *et al*. (2005, p. 614) suggest:

"Most problems in the innovation system will not be uni-dimensional but will consist of a complex mixture of causes and effects, and involve several actors."

Although there are differences between these conceptualisations of the AIS, several common “enabling factors” and disabling factors” or “barriers” to AIS performance can be discerned (see Table 1).

Table 1 Enabling and disabling factors for AIS performance (adapted from Klerkx et al., 2012b)

Enabling factors	Disabling factors
• Learning within and between firms and organisations in order to innovate • Strengthening individual and collective capabilities to innovate • Demand and supply-driven science and technology • Innovation agents focusing on complex and dynamic interactions • Network-based knowledge dissemination • Both embedded and dis-embedded knowledge dissemination: in both tacit and codified forms • Decentralized management of innovation processes	• Infrastructural: ○ Lack of investment in both physical structures (roads, telecoms) but also research and development facilities and financial infrastructure • Institutional: ○ Ranging from “hard”, formalised laws or regulations or lack of IP protection, to “soft” norms, values and culture that hamper innovation • Capabilities: ○ Lack of technical or organisational capacity to adapt to or manage new innovation • Market: ○ Relations between market participants, lack of trust/transparency or monopoly

Because a systems perspective places emphasis on interaction between the component parts of a given system, "... creating and fostering effective linkages amongst heterogeneous sets of actors" is the primary goal of AIS enquiry; however, this can also be hampered by social, economic, technical and cultural divides (Klerkx et al., 2012b, p. 468; see also Oreszczyn, Lane, & Carr, 2010). These can happen due to the use of different incentive structures for private and public actors, or between formal (scientific) and informal (indigenous) knowledge (see Section 4.7.1.2). Going further, Hall (2007) outlines the types of organisational attitudes and practices that "restrict" or "support" innovation (some of which emerge in this research) (see Table 2).

Table 2 List of restrictive and supportive attitudes and practices for agricultural innovation (adapted from A. Hall, 2007)

Restrictive attitudes and practices	Supportive attitudes and practices
• Mistrust of other organizations • Closed to other's ideas • Secretiveness • Lack of confidence • Professional hierarchies between organizations and disciples • Internal hierarchies • Top-down cultures and approaches • Failures are covered up • Limited scope and intensity of interaction in sector networks	• Trust • Openness • Transparency • Confidence • Mutual respect • Flat management structure • Reflection and learning from successes and failures • Proactive networking

Systems-orientated approaches to agricultural innovation are now established in European (EU SCAR, 2012), African (Kebebe et al., 2015; Kilelu et al., 2013; Sumberg, 2005) and Australasian research (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a), as well as being promoted by the World Bank (World Bank, 2012). A key strength of these approaches, at least from the perspective of this project, is the comprehensiveness with which they treat the possible sources of innovation – the final topic of this literature review.

2.4.3 Sources and drivers of innovation

As Kline & Rosenberg (2000, p. 283) stress "… it is a serious mistake to treat innovation as if it were a well-defined, homogenous thing that could be identified as entering the economy at a precise date – or becoming available at a precise point in time". How then, can the sources of innovation be explored?

Sources of innovation (if one is interested in a more robust answer than: "humans") are not necessarily the focus of any academic tradition: rather, each tradition has its own foci regarding the *direction* and nature of innovation. For the neoclassical economists, rational and self-optimising agents – with an emphasis on the "firm" – allocate an optimal amount of resources to the innovation process in order to enhance individual and social welfare through technological change. A key assumption here is that such actors can make rational choices with the (presumably complete) information they have at their disposal; as shown above, this is not presumed to be the case in other disciplines. Here, the attention is not on sources of innovation itself, but on the sources of *economic growth* (Edquist & McKelvey, 2000, p. 225).

For evolutionary economists, innovation is highly path dependent, meaning there are limited 'avenues' down which technological change might be directed. Such change is subject to 'selection' by the economy, but as proponents of the multi-level perspective would have it, radical innovation originates within protected "niches" of learning and experimenting that are sheltered from these selection pressures until they are able to 'stand alone' in the market. Incremental innovations, in this tradition, are seen as inevitable 'artefacts' of the *regime* in which they are nested.

In the *Systems of Innovation* tradition, it is recognised that "the manner in which innovations are generated differ significantly from one industry to another" (Kline & Rosenberg, 2000, p. 280). However, Freeman (Freeman, 2000, p. 46) offers something a little more concrete in discussing data that began to emerge in the 1970s and 80s:

"... it became increasingly evident that the success of innovations, their rate of diffusion and the associated productivity gains depended on a wide variety of other influences as well as formal R&D. In particular, incremental innovations came from production engineers, from technicians and from the shop floor… formal R&D was usually decisive in its contribution to radical innovations but it was no longer possible to ignore the many other contributions…"

If the sources of innovation differ slightly according to the above theories, the drivers of innovation do not: these are primarily 'economic', with innovation providing some sort of competitive advantage for the innovating party. As the findings of this research show (see Section 4.4.1), this is no different for the UK fresh produce industry, though there are other, significant drivers of innovation to be considered.

At least one author has gone beyond these perspectives to examine the sources of innovation in a systematic manner. Eric von Hippel's *Sources of Innovation* (1988) sought to elucidate the origins of products belonging to several categories of equipment[7]. A notable finding of this work is that it is often the practitioners working *with* certain equipment who either develop or modify the products they use in daily life. One might choose to link this to a major shift in thinking about agricultural innovation during the 1980s, in which the previously dominant model of agricultural development was challenged (see 2.4.2) in light of observations about farmers as sources of change (see Chambers et al., 1993). However, von Hippel goes on to list the multitude of sources of innovation across a number of sectors, finding that the functional source of innovation varies by industry. This, one might argue, is more in keeping with the 'systems' perspective, which takes innovation to be the result of collaboration between different industry actors. As Hall (A. Hall et al., 2006) notes:

[7] von Hippel defines the innovator as the individual or firm that first develops an innovation to a useful state – this is what he calls the "functional" source of innovation.

"Innovation requires knowledge from multiple sources, including from users of that knowledge; it involves these different sources of knowledge interacting with each other in order to share and combine ideas; these interactions and processes are usually very specific to a particular context; and each context has its own routines and traditions that reflect historical origins shaped by culture, politics, policies and power."

A weakness of von Hippels work, relative to systems-orientated approaches for example, is that it disregards institutional, society or organisational innovation, focussing exclusively on products instead – it likewise diminished the role of knowledge in innovation. Rosenberg (Rosenberg, 1994, p. 12) suggests that the stock of "presently available" scientific knowledge *must* present some constraints as to what is technologically possible, simultaneously permitting a range of technological alternatives to be "… taken up within the frontiers of that knowledge". It is in this sense that *research* – if aimed at generating knowledge – feeds into the innovative process, becoming a prime tool in social and technological change. Audretsch (1999) claims that the most important 'input' into the innovation process is new economic knowledge, and that the primary source of new economic knowledge is R&D.

However, systems-orientated approaches have opened the eyes of researchers to the multiple sources of new knowledge that exist (see Biggs, 1990; A. Hall, 2007). Rather than seeing researchers and universities as the ultimate sources of such knowledge, or firms or even farmers, innovation occurs through the interaction of these agents:

"... innovation as a social process of integrating different pieces of information held by different people, is subject to the whole range of social and institutional factors that pattern people's behaviour and interactions." (referencing Engel, 1997; A. Hall, 2007, p. 7)

Hall (2008, p. 17) goes as far as to suggest that there is no longer a single source of information and technology. The linear model of innovation, in particular, fails to capture such complexity. As Ingram (2014) suggests, the linear model of innovation does not account for the multiple goals and interactivity of modern agriculture.

2.4 Concluding remarks

This chapter has described the main features of the fresh produce industry and the changing nature of agricultural research in the UK.

It then tackled the problem of defining innovation – as well as its importance – before describing classical approaches to studying growth, beginning with the neoclassical tradition that failed to adequately take account of technological change and subsequent development of evolutionary economic theory, which sought to capture some of the complexities of technical change that neoclassical economists could not.

Next, it turned to the broader theories of technological change, which have attempted to explain real-world innovation, starting with *Diffusion* theory and moving onto *National Systems of Innovation* and *Innovation Systems* approaches, before turning to the more recent Multi-level Perspective.

The history of how innovation in an agricultural context has been approached was then investigated, beginning with extension science and moving onto more systems-orientated approaches to agricultural innovation like FSR, AKIS and AIS.

Lastly, what is understood about the sources and drivers of innovation was discussed.

This chapter has demonstrated a trend *away* from reductive theories of change in recent years, particularly in the realm of agriculture, which, as an industry, is increasingly called upon to deliver the competing demands of food production, environmental protection and rural development. Innovation systems theories have at the same time found a home in diagnostic work relating to agricultural problems and have embraced the complexity of multiple-actor innovation.

Of particular relevance to this study is the changing nature of agricultural extension, which, as noted earlier, has undergone significant change over the last several decades in Europe. The call for new forms of organisation in order to meet the challenges faced by the modern agricultural industry.

Chapter 3: Methodology and Methods

3.1 Introduction

In this chapter, the methodological approach used in the project is outlined, with justifications given for the use of specific methods. It begins by exploring suitable conceptual frameworks with which to frame the study before providing an explanation of the case study method and describing the type of data this approach might require.

It then outlines the process of conducting semi-structured interviews, including the ethical considerations of this type of study, before discussing how the data is analysed using the Framework Analysis approach.

3.1.1 Methodological requirements

Chapter 2 (Literature Review) has explored the various approaches to understanding innovation. It has been studied in a variety of ways and at a range of scales. It has been studied by social scientists from various fields, including innovation studies, economics, rural sociology, business studies and history (Malerba & Brusoni, 2007). It is clear that more than one discipline – and different types of data – offer the means to scrutinise questions about innovation. Those disciplines most relevant to this project (i.e. those that concern innovation in an agricultural setting), such as AKIS and AIS, emphasise the importance of interaction amongst constituent parts of the agricultural "system", appreciation for the diverse sources of innovation in agriculture and the learning processes at the heart of innovation. However, it is important to outline the exact methodological and empirical needs arising from the research questions. As Schensul (Schensul, 2008, p. 517) notes, research methodology:

"… consists of the assumptions, postulates, rules and methods – the blueprint or roadmap – that researchers employ to render their work open to analysis, critique, replication, repetition and/or adaptation and to choose research methods."

This chapter outlines the methodology taken to answering the research questions underpinning this project, which are:

1. What are the sources of innovation in the UK fresh produce industry?
2. What are the barriers to innovation in the fresh produce industry?
3. How can innovative capacity be enhanced?

Given the emphasis of the relevant literature, and focus of the research questions on the contextual circumstances of innovation, several interconnected requirements emerge with regards to methodology and the data it should provide:

1. *Guiding framework or theory*: 'innovation' has been studied in numerous ways, each with a specific focus. In order to situate itself theoretically, some kind of conceptual/analytical framework or working theory is required to properly hone the research methodology.

2. *Data of sufficient 'resolution', or depth*: certain approaches to understanding innovation processes do so at 'low resolution' in order to understand broad trends. However, the research questions suggest a need for data that can provide a contextual, specific understanding of innovation processes in the UK fresh produce sector.
3. *Applied in practice*: since the project seeks to provide recommendations to real-world organisations, it should be rooted in a 'real world', applied setting.

A suitable research methodology that was capable of providing the necessary data to answer these questions was established through a series of research decisions informed by published literature. It combined several approaches to social enquiry from different, but often-complementary fields that can be broken-down into three components:

1. *Conceptual framework*: an Agricultural Innovation Systems (AIS) approach.
2. *Methodology*: an embedded case study of innovation in UK fresh produce.
3. *Data generation and analysis*: primarily applied qualitative research using Framework Analysis to generate case data.

These decisions are explained below, beginning with the broadest assumptions of the project and moving onto the particulars of the research design.

3.2 Conceptual framework

In terms of guiding framework, several stand out as potentially suitable on the basis their relevance to innovation in agricultural settings: *Technology Transfer/Diffusion* approaches, *Agricultural Knowledge and Information Systems* (AKIS), *Agricultural Innovation Systems* (AIS) approaches, and *Farm Systems Research* (FSR), each of which is summarised in Table 3.

Of these frameworks, AIS provides the most coherent, yet flexible, analytical framework to explore contemporary agricultural innovation.

As Table 3 indicates, the "Technology Transfer" (TT) paradigm associated with the *Diffusion* model of technological adoption (first column), can be used to examine innovation in agriculture, but does so from the now rather limited position of the *research-extension-farmer* model of agricultural development. It treats as decided the sources of innovation – namely, research and researchers – and, at least in early iterations of the approach, ignores the *context* in which such technologies must be placed.

Table 3 Outline of four approaches to agricultural innovation, adapted from Schut *et al*. (2014b)

	Technology orientated	**Systems-orientated**		
Approach	Transfer of Technology (TT)	Farming Systems (FSR)	Agricultural Knowledge and Information Systems (AKIS)	Agricultural Innovation Systems (AIS)
Era	1950s – 1980s	1980s – 1990s	1990s – 2000s	2000s - onwards
Key objectives	Transfer, diffusion and adoption of technology	Contextualise agricultural research and technology	Build local capacities, empower farmers	Enhance systems capacity to generate and respond to change
Scope	Increase global agricultural productivity	Identify and alleviate livelihood constraints	Collaborate and integrate different types of knowledge for sustainable development	Generate institutional change
Core elements	Technology packages, efficiency of research transfer	Locally adapted knowledge and technology	Joint knowledge production and learning, value chain approach	Institutional analysis, stakeholder analysis
'Flow' of innovation	Top-down	Top-down	Bottom-up	Multi-directional
Key intervention approach	Extension to disseminate technology Mass media to facilitate adoption	Farmer consultation to inform research Surveys to develop farm typologies, impact of innovation	Participatory research Joint learning activities	Establish multi-actor innovation platforms
Role of farmer	Adopters of technology	Adopters of knowledge and	Experimenters	Partners

		technology Sources of information	Experts	Entrepreneurs Part of innovation network
Role of research and researcher	Develop knowledge and technology	Experts	Capacity builders Facilitators of learning	Actors to enhance innovation capacity Members of innovation network
Strengths	Enables rapid technological progress Enhances agricultural productivity	Technologies are developed in context	Integrates different types of knowledge, skills and experiences Contextualises the approach and considers dynamics of value chain	Multi-level focus Considers institutional and political dimensions of change Enhances resilience of the agricultural system
Weaknesses	Disregards farmers in technology development Disregards adoption context	Focus on farm and field level; limited attention for multi-level interactions	Local focus; limited attention for multi-level interactions Ignores structural power inequalities between actors Entails high costs	Complicates delineation of system Lacks empirical evidence of practical impact and value

Approaches associated with Farm Systems Research (FSR) (second column) display a narrow focus on farm context(s), and less on wider, multi-level issues. However, on-farm issues routinely transcend the farm itself, and whilst more recent FSR has incorporated an understanding of those very issues, it is increasingly aligned with the AIS perspective and other systems approaches (Darnhofer et al., 2012; Klerkx et al., 2012b). Agricultural knowledge and information systems (AKIS) are primarily concerned with the development of knowledge and information in the agricultural system, and particularly on the functioning of extension services. A lot can be taken from this perspective that is, in many ways, a natural sibling to AIS. However, the AIS tradition departs from AKIS in placing emphasis on interaction amongst all the various actors within the agricultural domain that contribute to innovation. Innovation systems approaches have been employed to identify and offer solutions to complex agricultural problems, variously termed "barriers", "bottlenecks" and "systemic problems" in agricultural systems in both the developed (Lamprinopoulou et al., 2012) and developing world (Hounkonnou et al., 2012; Kebebe et al., 2015). As such, AIS is a product of considerable research into agricultural innovation, and is an appropriate vehicle for exploring the barriers to innovation in the UK fresh produce industry at this time:

"… the AIS approach has proved its value as a comprehensive framework for analysing strengths and weaknesses in agricultural innovation systems in different contexts." (Klerkx et al., 2012b)

It was noted earlier that there are also several ways of conceptualising the

AIS depending on purpose (Section 2.4.2), there being a *infrastructuralist*, *process* and *functionalist* view of innovation systems. Turner *et al*. (2015a) and Kebebe *et al*. (2015) both represent very relevant examples of the latter: by developing an analysis of systemic barriers in specific innovation systems, the authors were able to pinpoint problem areas and offer targeted policy recommendations to relevant parties. Given the similar goals of this project, the *functionalist* view of innovation systems offers a clear way forward.

There are several implications that stem from the choice of 'innovation systems' thinking and, to a lesser extent, a *functionalist* view of such systems.

3.2.1 Adoption of 'systems thinking', ontology and epistemology

Systems thinking encourages the researcher to make claims about the topic under scrutiny, both at the ontological and epistemological levels: is the system of interest an *actual* system – i.e. "real" in the ontological sense – or is the use of the word "system" merely a heuristic *device* to help us understand complex phenomena? As Darnhofer *et al.* (2012, p. 12) point out:

"The system is thus defined for the particular purpose of the study, but not assumed to exist per se*. It is only a heuristic device that is effective in describing, classifying and discussing, thereby allowing the enhancement of understanding. This approach is based on a dynamic understanding between the researcher and the situation that is studied."*

In this project, the use of 'systems thinking' is considered an epistemological device (*systems as epistemology*), a tool used to frame one's understanding of a complex set of interactions and processes that make up an industry (Ison, 2010). As such, one might describe the underlying ontological position as *constructivist*: innovation is a co-negotiated process between different system actors, with different world-views and agendas, whose activities are shaped by 'environmental' factors such as policy, which they may attempt to reform (Klerkx et al., 2010). As noted earlier (Section 2.4.2), recent systems thinking in agriculture has tended towards viewing systems as "soft", implying that the actors that make up a given system will understand the boundaries and purpose of that system differently, potentially leading to conflicts (Klerkx et al., 2012b).

The focus on system actors corresponds to *critical* or *subtle* realism[8]. As (Ritchie & Lewis, 2003, p. 13) note, critical and subtle realism – developed by Bhasker (1978) and Hammersely (1992), respectively – argue that:

"…social phenomena are believed to exist independently of people's representations of them but are only accessible though those representations."

[8] Given the assumptions of the epistemological positions already described, critical realism is the preferred ontological position for this project; whereas *subtle* realism assumes that, although social phenomena *do* exist independently of the observer, interpretation of those phenomena is limited to one's own experience of them, *critical* realists assume that the more interpretations one can account for, the closer to that "reality" one gets.

Indeed, Koustouris (2012) explicitly calls for the use of critical realism in AIS analysis. Such a position was chosen because this project seeks to understand "real world" phenomena, whilst it must be acknowledged that this can only be done by interacting with people who have experience of those phenomena (e.g. barriers to innovation in the fresh produce industry). As such, the research participants' representations of these issues – the meaning they attach to them – are an inevitable product of researching the topic. It is both the interpretation of these phenomena and what those interpretations can tell us about the "real world" that are of interest. Systems thinking is also useful in a methodological sense, because it enables the researcher to define, in conceptual terms, what Schensul (2008) describes as *study site* (where and when the research takes place), *study population* (the groups or individuals of interest to the researcher with respect to research question) and *study sample* (the units of analysis, often people but can include events and other phenomena of interest).

Another facet of 'systems thinking' is *reflexivity*. Embedded, as the project is, in the social sciences, reflexivity enhances academic rigour by inviting researchers to make clear their position on certain factors before, during and after primary data collection and analysis. The importance of reflexivity is enhanced in light of the 'systems as epistemology' viewpoint. If the 'system' is heuristic a tool to understand the world, then the researcher is, themselves, a component of that system and therefore not a *neutral* observer of it (in contrast to how a biologist my think of themselves with regards to an ecological system, for example) (see Ison, 2010). As Ritchie & Spencer (2003, p. 13) observe:

"Some early commentators believed that the social world was similar to the physical world and was governed by universal, causal laws. Most contemporary qualitative researchers maintain that the social world is regulated by normative expectations and shared understandings and hence the laws that govern it are not immutable."

Other important considerations of the 'systems' approach concern boundaries[9]. A boundary denotes the limits of the system of concern. It helps the practitioner determine what is inside and outside the scope of research, and can be used a tool for determining study *site*, *population* and *sample*. However, determining the limits of certain systems can be troublesome (Ison, 2012).

As the title of this project indicates, the focus of concern is the current UK fresh produce industry, which represents the *study site*. However, in the interests of defining boundaries, a more comprehensive description follows:

1. *Primary industry*: this includes the production of horticultural goods, including vegetables, potatoes, fruits, ornamentals
2. *Support services*: these include seed and input suppliers, levy organisations, research institutes and researchers, non-government organisations and civil society groups

[9] As an attendee of the 'Systems Thinking in Practice' PhD course associated with the 12th biennial *International Farm Systems Association* (IFSA) conference at Harper Adams University (Shropshire, UK) in 2016, the author was involved in workshops devoted to the design and application of systems thinking in agricultural research.

3. *Processing, packing, marketing and sale*: this includes companies that receive, process and pack horticultural goods, as well as those that market and sell such goods – primarily retailers – and those that consolidate supply such as marketing desks and producer groups.

The fresh produce industry can be considered a *sub-system*[10] of the wider UK agricultural sector (which includes livestock, dairy, poultry and arable industries). Certain actors, it should be noted, transcend not only the horticultural sub-sector and wider UK agricultural sector but also permeate the international farming industry. Today, many businesses source or produce agricultural products both nationally and internationally. As such, the scope includes those organisations that interact with the fresh produce sub-system in some way, and even though this represents a "fuzzy" boundary, it is deemed necessary because these organisations have considerable influence on the sector and act as channels through which information can travel from beyond the UK.

The range of actors involved in determining innovation processes is large (certainly far beyond primary producers and the more obvious support services). In this respect, the boundary of the sub-system has continued to be shaped by primary data as it was gathered, for as (Darnhofer et al., 2012, p. 12) concludes, such choices "… may be revised, whenever it seems useful.". As such, people involved in this sub-system represent a viable *study population*, providing useful inclusion and exclusion criteria for the research

[10] "Fresh produce industry" will continue to be used for the remainder of the thesis but is considered synonymous with "fresh produce/horticultural sub-system".

design (see below).

3.3 Methodological considerations

In the previous section, the assumptions stemming from the choice to use an AIS approach were made clear: however, as an analytical framework AIS does not, itself, provide a methodological outline. Yet there *are* certain methodologies typically associated with the AIS tradition that are used in much of the work undertaken in innovation studies with an agricultural focus.

3.3.1 Social research and the case study approach

A number of research methodologies and methods exist in the social sciences (Yin, 2009). The choice of which to utilise depends upon:

- *The type of research question posed*
- *The extent of control the researcher has over actual behavioural events*
- *The degree of focus on contemporary as opposed to historical events*

Yin (2009) distinguishes between five major research strategies, being the case study, experiment, survey, archival analysis and historical study (see Table 4 for a breakdown of three such strategies).

Table 4 A comparison of case study, survey and experimental approaches. Adapted from Gomm *et al.* (2011)

Case study	Survey	Experiment
Investigation of a small number of cases	Investigation of a large number of cases	Investigation of a small number of cases
Information gathered and analysed about a large number of features of each case	Information gathered and analysed about a small number of features of each case	Information gathered and analysed about a small number of features of each case
Study of naturally occurring cases or of cases created by the researcher but where primary concern is not controlling variables	Study of naturally occurring cases with primary concern the maximisation of sample representativeness	Study of cases with primary concern the control of important variables
Quantification of data is not a priority	Qualitative data may be a priority, quantification not a priority	Quantification of data is a priority
Aim is theoretical inference or evaluation of an intervention	To understand the case in itself, or generalisation/transferability to wider domain	Aim is empirical generalisation (sometimes as a platform to theoretical inference)

Of the approaches outline in Table 4, it is clear that experimentation is not a practical solution to the research questions associated with this project: it is not possible to control variables in the aforementioned conception of the (inherently social) AIS. Social surveys do offer a means of tackling the research question, as questionnaires (commonly associated with survey design) provide a means of gathering views on innovation. However, surveys also require a prior understanding of the phenomena under scrutiny to develop (closed) questions, and as such do not allow the researcher to pursue emergent themes that may appear otherwise. The focus of this study on contemporary, rather than historical, circumstances suggests a study of history is likewise inappropriate. If one were interested in tracking the development and adoption of a specific technology or practice, then archival analysis as outlined by Yin (2009, p. 8) could be a viable strategy. However, this is more in keeping with the *Diffusion/Technology Transfer* approach to agricultural innovation (outlined above) and does not offer the means to scrutinise contemporary events. It is worth pointing out that archival data can be included in a case study. A case study is defined as:

"… a strategy for doing research which involves an empirical investigation of a particular contemporary phenomenon within its real life context using multiple sources of evidence… the case is the situation, individual, group, organisation, or whatever it is that we are interested in." (Robson, 2011, pp. 135-136)

Case studies are common in FSR (Darnhofer et al., 2012, p. 106) and AKIS and AIS work, as well as the *Technology Transfer/Diffusion* traditions and in international development work. To give just a few examples:

- *A series of case studies involving 20 innovation "intermediaries" in the Dutch agricultural sector* (Klerkx & Leeuwis, 2008b)
- *A case study of the Dutch vegetable breeding innovation system* (Liu, Jongsma, Huang, Dons, & Omta, 2015)
- *A case study of social learning through joint-experimentation in Benin* (Akpo, Crane, Vissoh, & Tossou, 2014)
- *A case study of socio-economic and policy constraints to dairy development in Ethiopia* (Kebebe et al., 2015)
- *A case study examining knowledge flows between agricultural research and extension services in Italy* (Materia et al., 2014)

Why is the case study so popular in agricultural innovation studies? In essence, it is because these approaches perceive innovation as a social process and require some unit of analysis or frame of reference; one cannot study every possible innovation process going on in a certain place at a certain time. Cases are therefore used in order to particularise, generalise or build theory, depending on the aims of the project in question, often with the intention of informing policy.

The case study approach is useful when the research question seeks to explain some present circumstance (the "how" and "why" of a social phenomenon) (Yin, 2009, p. 4). Case studies are often used where variables cannot be controlled and the researcher cannot influence events. Qualitative research in general and the case study approach in particular reject in part or completely the notion of immutable, generalisable laws (at least in the social world) (Lincoln & Guba, 2011). As such, "local conditions" prevail. In circumstances where little is known about a specific topic – where *a priori* issues have not been explored, say – case studies provide a means of identifying important issues, being expansionist rather than reductionist in nature (Gomm et al., 2011, p. 24).

As Gomm *et al.* (2011, pp. 3-4) note, case studies can differ markedly in their aims and content, in the number of cases and their respective level of detail, whether the case is longitudinal or not, the extent to which researchers document the social context of each case and whether analysis goes beyond description and explanation to evaluation and prescription. However, Gomm *et al.* (2011, p. 5) also point out that such parameters are determined by the aims of the project, and if the focus is "… some problem in the situation investigated, then the discussion will be geared towards diagnosing that problem and identifying its sources and what can be done about it". Yin (Yin, 2009) delineates four types of case study:

- *Single-case designs with one unit of analysis (holistic)*
- *Single-case designs with more than one unit of analysis (embedded)*
- *Multiple-case designs with one unit of analysis (holistic)*
- *Multiple-case designs with more than one unit of analysis (embedded)*

It is tempting to think of multiple-case studies as conferring greater reliability by using more than one case (and increased transferability) (see Yin, 2009, pp. 53-54). Yin goes on to outline the rationale for choosing amongst these options: single-case studies are used when the subject under scrutiny is considered average, unique, deviant, revelatory or as a test for existing theory: multiple-case studies are common in situations where one wishes to test theoretical predictions through literal or theoretical replication.

Two of these options were considered potentially relevant: the "embedded" single-case design with more than one unit of analysis and the "holistic" multiple-case study with one unit of analysis. In the former, the UK fresh produce sub-system itself could be considered the case study within the wider agricultural sector, with embedded components and multiple data sources. In the latter, multiple cases could be selected from amongst the parts of the innovation system for analysis and comparison with one another.

However, multiple-case studies have a heavy focus on theory, which is necessary to guide the *literal* replication of cases (where they are presumed to confirm predicted results) or *theoretical* replication of cases (where they are presumed to offer contrasting results) rather than applied outputs. Secondly, if representation through proper sampling is needed from a target group, say, people involved in an innovation sub-system, each case would *have* to include information about both the context of that case (such as detailed background information) and the relationship between that case and the phenomena under scrutiny, throwing up an "impossibly" large number of variables (Yin, 2009, p. 56). As such, a **single case study with embedded units of analysis** is preferable: being able to use different units of analysis under the umbrella of a single-case study permits the use of various data sources in direct reference to the case, where appropriate. Likewise, if some form of representation in a possible sample of subunits is required – which is appropriate given the nature of innovation as perceived through the AIS lens – then some measure of sampling from amongst those subunits is necessary (see below).

The case can be considered to be *intrinsic* – a logical extension of the research questions, which, as stated, describe the case: *innovation in the fresh produce industry*. With respect to 'systems thinking', the case corresponds to what Ison (2010) calls the *situation*, which should not be confused with the heuristic device of the *system*.

Here, it is worth bearing in mind Yin's (2009) warning: if too much attention is given to subunits of the case, larger, holistic aspects of the case begin to be ignored, and thus the focus of the study will "shift". If this shift is justified, Yin notes, it must be expressed explicitly. In response to this, it is possible to defer to an earlier pragmatic epistemological assumption: that "…social phenomena are believed to exist independently of people's representations of them but are only accessible though those representations." As such, to understand *this* case we may have to accept that the sub-units, if they are people, may 'shift' the research in their direction.

3.3.2 What type of data?

The strength of the case study approach lies in the broad range of empirical evidence that can be used to contextualise, explain and evaluate the phenomena under study. However, thought must be given to what types of data can best inform a case study of the UK fresh produce innovation system. Case studies often use certain qualitative methods of data generation, particularly interviews but also document analysis and participant observation.

Of those disciplines that focus on innovation, two groups emerge: those that rely primarily on quantitative data and those that primarily rely on qualitative data. The former is often considered to sit in the *positivist* or *post-positivist* paradigm in which objective knowledge can be gleaned by observation in a "value-free" way; the latter based in the *constructivist* view that social properties are 'constructed' through people's interactions, rather than existing separately (see Robson, 2011, pp. 20-25). As Dörnyei (2007, p. 24) suggests, this is perhaps the best-known distinction in research methodologies.

In economic approaches, used in pure economics and in some business studies, large-scale quantitative data are used to chart broad trends in agricultural productivity and technical change (see Alston et al., 1999; Alston, Beddow, & Pardey, 2009). Such methods tend to rely on numerical, archival data, and do not typically offer the depth needed to explore sector-specific barriers to innovation that can be social in nature (such as policy or level of farmer education).

Certain quantitative approaches *have* been used in high-resolution studies, but concern farmer behaviour, adoption of technology and those adoption factors that can be quantified to produce some kind of model (see Ghadim & Pannell, 1999); these miss 'systemic' factors that have been identified as important in other disciplines (Klerkx et al., 2010). In such cases, the *research-extension-farmer* (or *Diffusion*) model of innovation tends to dominate, because the uptake of a particular technology or practice can be quantified either in an absolute sense (Calleja et al., 2012) or amongst a certain population (see Röling, 1988, pp. 1-18). Hall & Rosenberg (2010) outline current economic thought in a range of areas, including agricultural economics, but it is clear that economic approaches, as valuable as they are at scale, have limited capacity to elucidate the *operational* context of innovation. Likewise, these data are longitudinal rather than cross-sectional. In the case of *Technology Transfer/Diffusion* research, such data are used to plot the adoption of a specific technology or practice over time. However, as Dörnyei (2007, p. 78) notes, cross-sectional methods provide a "snapshot-like" analysis of a target phenomenon at a particular point in time that allows the researcher "…to establish relationships between variables", which is an important consideration in light of the research aims of this study.

Some studies use both quantitative and qualitative techniques of enquiry (*mixed-methods research*): Temel, Janssen & Karimov (2003) combine the assumptions of systems thinking (i.e. how components of a system interact is important) with 'graph theoretical' techniques to provide a breakdown of the relative strength of the linkages between components of the Azerbaijani AIS. However, this method, which is not yet widespread, relies on closed questionnaires to provide the bulk of the data with which to generate a matrix of innovation system performance (though semi-structured interviews provide supplementary data for weighting). As such, this method relies on receiving good, representative recipient response rates to the questionnaire. Also, the closed-nature of the questionnaire restricts the researcher from identifying emergent issues or to probe for deeper responses.

An alternative to these approaches is found in methodologies associated with applied qualitative or social research, which tend to be more common in the AIS diagnostic work given the theoretical, constructivist assumptions of systems thinking outlined above. As the name suggests, applied qualitative research relies primarily on qualitative methodologies, and provides a means to answer complex questions in a robust manner; in particular, these methodologies can answer questions of both an *evaluative* nature (i.e. how well is a certain process working/how can this be improved?) and a *generative* nature (i.e. can new solutions to existing problems be found?) (see Ritchie & Lewis, 2003, pp. 30-31). This approach fits well with the aims of the project.

Given the need for depth and application to real-world problems, applied qualitative research within a case study design, underpinned with the AIS framework, offers a suitable methodology for approaching the task of data collection, analysis and summation. However, the choice of framework brings with it several implications, as does the decision to adopt an applied qualitative methodology.

3.4 Research design

The research design refers to the specific methods used to collect and analyse primary data in order to answer the research question(s). A good qualitative research design has a clearly defined purpose, with coherence between the research questions and the methods used to answer them, and which also generates valid and reliable data (Ritchie & Lewis, 2003, p. 47). Research design in qualitative research is not fixed, but responsive to the specifics of the research setting and unanticipated issues. As such, it is an iterative and continuous process that is not fixed at the earliest stages of research. While the ideas present at the start of a project inform the initial research design, the "… relationship between design, data and theory is a multi-direction one" (Ritchie & Lewis, 2003, p. 49).

3.4.1 Case Data

Thought must be given to the appropriate means of generating case data and what form this should take. As Mason (1996, p. 36) suggests, the use of the word "generate" is more precise than "collection" with regards to data, as most qualitative perspectives reject the notion that the researcher can be a neutral "collector" of data; indeed, sufficient or relevant data cannot always be assumed to exist independently (of the researcher).

Mason (1996) also forms a distinction between methods of generating data, and the *sources* of data that those methods rely on. In qualitative research, the sources of data are often *people*, but can include a range of artefacts such as visual images, organisations or events. Here, it is important to ensure that choice of data source and methods to generate data from it are consistent with the ontological and epistemological positions of the research (Mason, 1996, p. 37). A number of ontological and epistemological assumptions stem from the choices made so far with regards to methodology: a 'system' is a heuristic device to delineate the boundaries of the topic of interest, and from this perspective an agricultural innovation system is made up of heterogenous social actors whom interact to further their agendas and shape their environment (*constructivist* ontology): however, because such a system is, necessarily, made up of people[11], one can only understand the system through people's interpretations of it (*critical* realism). Therefore, people do represent viable *sources* of data because their experiences, views, interpretations and interactions are meaningful properties of that system (Mason, 1996). In turn, the methods used to generate data from them must provide the means to interrogate their perceptions of the topic under scrutiny.

3.4.1.1 Qualitative interviewing

Informed by the initial literature review, requirements of the data and the explanatory power of applied qualitative research, it was decided that in-depth, face-to-face, semi-structured interviews provided a robust means to generate case data. Not only is this the most common – or at least complementary – method of primary data generation in AIS approaches (Dolinska & d'Aquino, 2016 for example; Klerkx et al., 2010; see Klerkx & Leeuwis, 2008b) but in qualitative research in general (Ritchie & Lewis, 2003, p. 36). Turner *et al.* (2015a, p. 3) observe that most diagnostic AIS work relies on semi-structured interviews. Semi-structured interviews provide a focus on the individual (case study sub-units or *informants* in the design) and, importantly, an in-depth understanding of the personal experience of the research phenomena (see Ritchie & Lewis, 2003).

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[11] In some systems theories, artefacts such as technology and/or infrastructure form important components of the 'system', such as in the Mutli-level Perspective (see Geels, 2005).

Qualitative interviews can explain social processes, change, organisation and meaning (Mason, 1996).

A key strength of semi-structured interviews is an emphasis on flexibility, which permits the researcher to explore emergent issues as and when they arise during an interview, thus tailoring each interview to the specific needs of that social interaction. Several assumptions arise from this choice of method, which are outlined by Mason (1996, pp. 41-42). For instance, researchers adopting such an approach to data generation tend to view depth and complexity as preferential (over broad, superficial surface comparisons). Likewise, they promote *reflexivity* as a means of analysing the role of researcher in the research process (see Section 6.2).

3.4.1.1.1. Interview Protocol and Guide

Once the decision to use individual interviews had been taken as a means to generate primary case data, an initial interview "protocol" was designed to layout the goals of the project and the means by which data were to be gathered (see D. Madsen & Lewis-Beck, 2004). It was also used to secure ethical approval from the appropriate parties (see below). The protocol outlined the nature of the questions to be asked during the interview, which were then further developed into an interview "guide" and basis for more explicit research design. The guide is an *aide memoire*, a list of topics or themes to be covered in a semi-structured interview that provides fluidity and organisation to the developing social interaction between interviewer and interviewee (Mason & Lewis-Beck, 2004).

The guide should enable the interviewer to make on-the-spot decisions and decide, for instance, whether something the interviewee has said should be followed up. An interview guide differs from an interview "schedule" in that the former is flexible – permitting the modification of questions and use of prompts as the situation dictates – as opposed to the latter, which consists of a series of formal questions to be asked verbatim (Fowler & Lewis-Beck, 2004; see Mason & Lewis-Beck, 2004). The interview guide was designed to explore topics that might provide data relevant to the research questions, as well as *a priori* issues stemming from relevant literature, outlined in Table 5.

Table 5 Topics, aims and example questions as used in the interview guide

Topic	Aim	Example questions
Nature of innovation	To open the interview with general questions about the perception, importance and impact of innovation in the industry	• How important is innovation? • What drives innovation? • What has been the most impactful innovation of the last twenty or so years? [probe/repeat]
Sources of innovation	To identify the origins of innovation	• Who/what contributes to innovation? [probe/repeat]
Enabling and	To explore what constrains	• What holds back

disabling factors for change	innovation, and what can bolster it	innovation? [probe/repeat] • What can enable innovation? [probe/repeat]
Communication in the industry	To expose the mechanisms by which different actors in the industry communicate their needs	• "Where do [you] or others go for solutions when they have problems?" [repeat] • "Is there a lack of communication or cohesion in the industry?" [probe] • "What relationships work well?" [probe] • "Whose responsibility is it to share [what] knowledge?"
Challenges for the industry	To determine the emergent challenges to the industry	• "What are the biggest challenges for the industry going forward?" [repeat]

Given the emphasis placed on iteration in qualitative research – the back and forth between data collection and analysis (see Dörnyei, 2007, p. 124) – as certain topics and questions became *saturated* (see below) new issues began to take prominence. Several other questions were targeted at specific people in specific roles: for instance, researchers involved in supporting the fresh produce industry through scientific projects and those associated with intermediary organisations such as levy boards or agronomic consultancies were asked about the process of translating science into practice, whereas growers were more commonly asked about the processes of implementing innovation on-farm. As Mason (1996, p. 40) suggests, in order to achieve data that are comparable it can be necessary to ask different questions of different people.

As advised, the interview guide was 'piloted' with the project supervisors in as close-to-real circumstances as possible (Mason & Lewis-Beck, 2004). Although piloting is deemed more important in quantitative studies, it is useful in qualitative research both in terms of calibrating the researcher's 'tools' and developing interview skills (Dörnyei, 2007, p. 75). Likewise, testing the interview schedule allowed the researcher to identify weaknesses in the proposed questions and adjust them before the study proper began.

3.4.1.1.2 Ethical considerations and confidentiality

Whilst it was felt that the types of subject to be discussed with interviewees as part of this project were not overly personal or harmful – as can be the case with, say, medical research – ethical considerations are important, especially in the social sciences, where social research inevitably concerns people's lives (Dörnyei, 2007, p. 63) (see also Appendix 3).

The initial project protocol was used to secure ethical approval from the University of Warwick *Biomedical and Scientific Research Ethics Committee* (BSREC); approval was granted in August 2014 (REGO-2014-1041), allowing interviews to commence. An 'information pack' was also designed and sent to potential interviewees before they took part in the project to ensure participants knew what kind of study was being undertaken, their role in said study and how the data they provided would be used. This included information about BSREC and their rights as participants in the project (see Appendix 3).

A separate consent form was also created to obtain the interviewee's consent to the use of their views in the study, to confirm that they had understood that they could withdraw from the study at any time – and thereby remove any data they have provided from inclusion in the analysis – and ask if they prefer to remain anonymous[12]. Together these documents ensure that the interviewee has granted *informed consent* as to their involvement in the project (Dörnyei, 2007):

3.4.1.1.3 Data recording, management and protection

As Schensul (2008) notes, the recording of qualitative data is important – it forms the primary data that will be analysed later. A *Sony* Dictaphone was

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[12] This was initially phrased as a question, but, when it became clear that some interviewees *did* wish to remain anonymous, this became the default position for data collection and management.

purchased to record the interviews in MP3 format for later transcription and written "fieldnotes" were taken during the interview itself for later consultation. As Ritchie & Spencer (2003, pp. 132-133) points out, fieldnotes are useful for recording what a researcher sees and hears during an interview or focus group, as well as ideas for later fieldwork and information that may become relevant at the analytical stage.

In the interests of confidentiality, the collected data were stored on a personal, password-protected University-managed laptop and backed-up via University of Warwick email client storage. Qualitative data analysis software, Nvivo 10 (for Mac), was used to manage the data analysis. The study protocol also dictates that the digital recordings and transcripts be deleted at the end of the project. Signed consent forms are held by the researcher in a secure location. Any personal identifying information was removed from the transcript at the time of transcription, and the author carried out all transcriptions.

3.4.1.1.4 Sampling

In qualitative research involving people, thought needs to be given to the method of selecting interviewees. The strategy employed in selecting participants is referred to as "sampling" or "recruitment", the process by which a researcher identifies and invites people to take part in a study (Eide, 2008).

Given the system boundaries defined in Section 3.2.1 and the assumption of *Framework Analysis*, described below, that practitioners involved in the project, business or sector of concern are the subjects of attention, two criterion sampling strategies were chosen to generate case data:

1. *Purposive sampling*: this strategy targets candidates based on certain characteristics – for example, their role and position in the fresh produce industry – rather than trying to achieve neutral, 'probabilistic' sampling. Several assumptions stem from the choice of this method, namely that 'the best' sampling strategy depends on the context in which the researcher(s) is working, and the specific research objective in mind (Palys, 2008). As Palys (2008, p. 967) notes, purposive sampling is "virtually synonymous with qualitative research", in part because qualitative researchers are less interested about the "central tendency" of a larger group and more interested in case study analysis (i.e. what a specific group thinks about a topic or the role they play in dynamic processes). A second presumption here is that who a person *is* and *where* they are located in a system of interest is important, rather than them being freely interchangeable. A benefit of this approach is that people in certain roles and specific locations can be targeted for inclusion in the project to ensure that a wide-range of voices is heard from across the sub-system to improve data *adequacy* (described below). The criterion used for selection in the study were:

    a. that they have a role in the fresh produce sub-system and knowledge of its workings (e.g. grower, researcher or agronomist)

   b. geographic location of operations (i.e. based in different parts of the UK)
   c. scale and position within business or organisation (e.g. technologist at large, international retailer or researcher at relatively small UK university)

   An attempt was made to maximize the diversity of individuals included in the study. A variety of roles, geographic locations within the UK and scales of operation were targeted to provide far-reaching, system-focussed data collection. Such an approach also enhances the internal validity of the project.

2. *Co-nomination sampling*: commonly known as “snowball” sampling, this strategy relies on the participants themselves to suggest other candidates for inclusion in the project (Eide, 2008). Considering the many barriers to recruitment (see Eide, 2008), it is important to build “strong coalitions and networks based in the culture and community”. Key contacts can provide assistance in the recruitment of potential participants, having people in this “liaison role” can be important for the success of participant recruitment and the overall success of the project.

Purposive and *co-nomination* sampling are recruitment strategies that fulfill the first essential criteria of two outlined by Eide (2008): *appropriateness* and *adequacy*. The chosen sampling techniques ensure that appropriate people, those who can best inform the study, are approached for inclusion in the project. However, guaranteeing the *adequacy* of the research relies on gathering enough data to provide a rich description of the phenomena under study; *saturation* – the continuation of data collection and analysis until no new information emerges – is a method used in qualitative research to determine when and if data collection is satisfactory. As Saumur & Given (2008b) point out, some researchers consider a sample of 15-20 sufficient to achieve saturations of themes, but note that sample size will inevitably vary from study to study.

It is worth noting that, due to the nature of recruitment, only those willing to respond to emails or calls and participate in the project can inform the research, so although this sampling strategy makes use of *purposive* and *co-nomination* sampling, the recruitment process resembles *convenience* sampling in a number of ways (see Saumure & Given, 2008a). A convenience sample is chosen on the basis of accessibility, proximity, availability and (crucially) willingness (Dörnyei, 2007, p. 99). Equally, as Eide (2008) notes, researchers must consider who, by virtue of their recruitment strategy, might be excluded from the study unintentionally (see Section 6.2).

3.4.2 Data analysis

All qualitative data can be manipulated and *coded* (Schensul, 2008), but the choice of protocol to do so is dependent upon the research question and study design, as well as the data itself. Qualitative research is far from a 'uniform' approach, but, as Dornyei (2007, p. 242) points out, nowhere is this diversity more apparent that when it comes to data analysis. Despite this diversity, there are similarities between different forms of qualitative analysis, being: primarily about the analysis of language (text), an iterative process that involves nonlinear, back-and-forth movement between data analysis and generation, and striking a balance between strict, formalised methodologies and intuitive, fluid analytical positions (Dörnyei, 2007). In any case, data reduction, display and interpretation are required.

For this project, *Framework Analysis* was chosen as a suitable means of interrogating the generated interview data. Developed by Ritchie & Spencer in the late 1980s, it sits within a broad family of analysis methods called *thematic analysis* or *qualitative content analysis* (Gale, Heath, Cameron, Rashid, & Redwood, 2013), which, although now closely associated with qualitative research began life as a *quantitative* method of analysis (Dörnyei, 2007, p. 245). Such approaches identify commonalities and differences amongst data, permitting the researcher to draw descriptive and/or explanatory conclusions around *themes* derived from the data. As Ryan & Bernard (2003) point out, theme identification is one of the most important tasks in qualitative research. A defining feature of the method is the ability to cross reference *cases* – typically an individual interviewee – with *codes* – indicators of meaningful information – in a matrix. This provides a structure for systematically reducing the data. *Cases* here refer to the units of analysis in the Framework Analysis approach, and not the *case* of a *case study*; the interviewees are *sub-units* of the case study. As an approach to qualitative data analysis, Framework Analysis was 'designed' for research projects that have:

1. Specific questions
2. A limited time-frame
3. A pre-defined sample (e.g. those associated with a company, programme or sector of concern)

4. *A priori* issues (e.g. themes that one can expect to occur as a result of the characteristics of the phenomenon being studied, already agreed-upon definitions and constructs and decisions made in light of existing theory (see G. W. Ryan & Bernard, 2003)

This research project has specific questions, a limited timeframe, sensitivity to certain *a priori* issues (i.e. those that stem from using AIS as a conceptual framework) and a pre-defined sample (people involved in the UK fresh produce innovation system). Framework Analysis is primarily concerned with analyzing the substantive, common-sense meaning in qualitative data, rather than focussing on the use of *language* itself (as in discourse analysis, for example) (Ritchie & Lewis, 2003, p. 202). Whilst Framework Analysis may contribute to the generation of theory its primary function is to explain what is happening in a certain situation, particularly where an expected output is improved policy measures (Srivastava & Thomson, 2009). In this respect, Framework Analysis 'lines-up' with case study methodology. As such Framework is a suitable option for the reduction, display and interpretation of the data, considering the context of the research questions and aims.

3.4.2.1 Using Framework Analysis

Ritchie & Spencer (2003) describe the process of transforming what is often at first messy, voluminous raw data into a more abstract, analytical form as conceptual scaffolding or "analytic hierarchy". This process enables the researcher to make sense of the data and provide an analytical account of what is happening.

In short, familiarisation with the data is used to develop an initial set of themes: this is the ‘framework’ by which subsequent data is categorised (*indexing*). Once no new information comes forward (i.e. once no new theme emerge) saturation has occurred and data collection can end. *Charting* is used to find cross cutting themes in the data, which involves creating a *matrix* of cases and exemplary thematic codes, by reading across cases and looking for similarities and differences in the framework, enabling the construction of higher-level concepts.

Each of these steps is described in more detail below:

- *Familiarisation with the dataset*: the researcher should familiarize themselves thoroughly with the data before any further analysis. If the researcher has been involved in transcribing the interview, then this provides an opportunity for early familiarisation. Ritchie & Spencer (2003) consider this the foundation of the analytic hierarchy.
- *Identifying initial themes or concepts*: the goal here is to establish a framework or ‘index’, drawing upon recurrent themes in the data and issues introduced into the interviews though the interview guide (these might be *a priori* issues). These early themes can then be sorted according to different levels of generality so that the index has a hierarchy of ‘main’ and ‘subthemes’; they should also stay close to the data in terms of language and substantive meaning (i.e. themes should be derived from the data and not superimposed from ‘above’ through theoretical positions). Indexes vary from those that have a

semantic focus, to descriptive categories that remain close to the data, to more abstract classifications (Ritchie & Lewis, 2003, p. 222).

- *Indexing*: this involves understanding what is meant by textual data and classifying the whole dataset according to the 'thematic sets', or categories, of the index established above. There is more than one way of carrying out this process, but it can be done using 'computer-assisted qualitative data analysis software' (CAQDAS), which ensures that the source of a particular piece of information is not lost. Of course, data is often interlinked, and it is worth noting where these interspersions occur for later analysis; likewise, some data may need to be assigned to more than one category.
- *Charting and synthesis*: next, it is possible to create a matrix to *chart* the main themes (and important associated subthemes – see Table 8 in Chapter 4) against cases (that is, individuals involved in the study). This allows the researcher to read across themes and cases to develop 'higher-order', analytical categorisations of the data. It is important here to retain the language of the respondents without quoting data verbatim (Ritchie & Lewis, 2003).

Once these steps have been taken with the whole dataset, it is possible to begin more a thorough process of developing explanations for accounts by reading across the synthesised data; Framework Analysis permits the rather rapid appraisal "up and down" the analytical hierarchy to make links between different concepts (Ritchie & Lewis, 2003, p. 256). However, developing full explanations for observed phenomena requires the researcher to also draw upon exiting literature and other theoretical frameworks to explain what they have found (see Discussion).

3.5 Concluding remarks

In this chapter, a methodological outline for answering the research questions has been provided and justified. This began with an exploration of the most fitting analytical framework through which to guide the study, including an explanation of the implications adopting a systems approach, as well as defining the boundaries of this system, before moving onto the case study method and data requirements of this approach. It then outlined the process of conducting semi-structured interviews, including the ethical considerations of this type of study, before discussing how this data can be analysed using the Framework Analysis approach. As such, the methodology and methods used in this thesis can be summarised as follows:

- Conceptual framework: Agricultural Innovation Systems
  - Methodology: embedded, single-case study
    - Methods:
      - Semi-structured interviews with industry practitioners chosen on the basis of:
        - Their role
        - Their location
        - Their position within business or organisation
      - Data analysis: Framework Analysis

The effectiveness of this approach, as well as its limitations, is discussed in in Section 5.4.

Chapter 4: Findings

In this chapter, the findings of the case study are explored. It begins by describing what was achieved in terms of data generation before moving onto the more substantive themes that emerged through the analysis of that data.

4.1 Data generation and analysis

The data generation period of the research ran from May 2015 – January 2017.

In total, 35 interviews were undertaken; 30 of these with people directly involved in the UK fresh produce industry at a position within the boundaries of the UK fresh produce sub-system identified in 3.1.2, three with experts in agricultural knowledge/innovation systems research[13], and two with a specific technology in mind (polytunnels). Some 70 people or organisations were approached for interview (primarily by internet searches and co-nomination sampling) representing a positive response-rate of ~50 per cent. Of those who were approached but did not take part in the research, most did not reply to the request for an interview, and for one a suitable time could not be found. Table 6 provides a breakdown of the various roles of those interviewed.

[13] These were not included in the main analysis but served as guides for innovation systems research.

Table 6 Breakdown of current role of participants (including expert and technology-specific interviews). It should be noted that many people involved in the project have had careers spanning more than one category outlined here, and this table serves only as a guide.

Industry role	Count
Grower/other farm business	14
Researcher	8
Producer organisation, NGO or policy	4
Agronomist/consultant	3
Retailer	2
Levy organisation	2
Breeder	2

Interviews took place at various locations within the UK (including England, Scotland and Wales) most commonly at the participants' place of work or at Warwick Crop Centre where the researcher was based. The interviews generally lasted around 50 minutes, ranging from 30 minutes to 1.5 hours. Of the 35 interviews undertaken in total, five were with women and the remaining 30, men.

4.1.1 Data management and analysis

The digitally recorded interviews were uploaded to the author's laptop, imported to *NVivo 10* (CAQDAS) and transcribed within the software. This produced over 900 pages of transcript. The transcriptions were assigned a 'codename' to preserve the anonymity of those who chose to remain anonymous – the number of each interviewee also follows any quotations used below. The transcripts were then analysed in accordance with Framework Analysis (see also Section 6.2), which produced 9 'higher-level' categories with numerous sub-themes (see Table 7).

Table 7 List of top-level categories and sub-themes developed during data analysis

Top-level categories	Sub-themes

Norms and institutions	• Specificity and difference within the fresh produce industry
	  ○ Market and industry trends
	  ○ Scale and size of farm businesses
	  ○ Distinctiveness of fresh produce sectors
	• Influence of retailers and other actors in the food supply chain
	• The role of the levy board
	• Long vs. short term vision

Innovation in fresh produce	• Defining innovation • Observations about innovation processes • Types of innovation • Impact and measurement of innovation
Drivers of change	• Economic drivers • Retail needs • Regulation
Sources of innovation	• Overseas sources of innovation • Learning by doing • Individual businesses and organisations • Formal research

Communication in the fresh produce industry	• Positive interfaces and successful brokerage ○ Networks ○ The role of different organisations and actors ○ Specific projects • Barriers to effective communication and collaboration
Industry bottlenecks	• Systemic barriers ○ Fragmentation ○ Formalised research ○ Economic factors ○ Regulatory constraints ○ Culture • Personal barriers
Enabling factors	• Systemic enabling factors • Personal enabling factors ○ Interactivity ○ Human and material resources ○ Champions as change agents • Trust • The idea of best practice: in farming and in extension
Comparisons with the past	
Challenges	

In the initial phase of the data analysis, the first five interviews were fully coded to generate an early set of codes through which to categorise or challenge subsequent data; these were was continuously refined as new codes were added to the dataset. Framework Analysis places emphasis on familiarisation and determining the larger, substantive themes at the outset of data analysis, but Ritchie & Spencer (2003, p. 229) also note that *interpretation* should be kept to a minimum at this point. As such, in an effort to remain 'true to the data', thematic categories were built up exclusively from the coded data in the first instance but were improved upon by consolidating themes into thematic categories and using *a priori* language to describe these thematic categories (i.e. "Norms and institutions").

4.2 Norms and institutions

A category emerged from the data relating to what we might call the 'nature of the industry', including observations about industry structure, relationships between the various actors involved in the fresh produce supply chain, market and industry trends, regulatory frameworks, and visions for its future; these have been labelled "norms and institutions" and can broken down into five further sub-sections:

1. Specificity & difference within the fresh produce industry
2. The influence of retailers and other actors in the food supply chain
3. The role of the levy board
4. Loss and waste of resources
5. Long vs. short term vision

Each of these sub-sections is discussed in more detail below.

4.2.1 Specificity and difference within the fresh produce industry

This theme stemmed from observations regarding the *specifics* or peculiarities of the industry – contrasted in the main against other agricultural sectors such as livestock or arable farming. It also concerns the differences between the sectors that make up the industry, and between larger and smaller growers. It is a useful starting point for this chapter, and the observations made provide context for subsequent sections; "Scale and size of farm businesses" (Section 4.2.1.2), for example, is a topic that frames many of those to follow.

The sector is, in general, considered highly innovative (particularly when compared to other categories of farming) and requires a high level of commitment and dedication to innovation. Connected to this, the fresh produce sector was seen to be more 'industrial' than other sectors of farming:

"So I think horticulture is different from the rest of the industry… because it's got a different structure, a greater degree of consolidation within each individual sector, and they see in- more in keeping with a typical industrial business, they see innovation and intellectual property as an opportunity to differentiate themselves in the marketplace." (8)

At the same time, horticulture is considered to be a more marginalized sector – compared to, say, arable farming – and is thought to have "fallen behind" in some way, impacted by less and less support from government by way of sector-specific research funding and the loss of institutions formerly undertaking that research (see Section 4.9).

Interestingly, there was no consensus on whether those involved in the industry were more or less willing to share knowledge:

"… I would say that the fresh produce industry is a very sharing industry and a very collaborative industry…" (2)

… or not:

"If they can get an advantage on their colleagues or on their competitors, that's what they're seeking to do. They operate… much more in... a sort of closed environment where they are seeking to generate intellectual property which gives them a market advantage, either because they can do things cheaper or because they can produce a better product." (8)

However, a common observation was that the industry was "small" in the sense that there remain close networks of people known to one another, and, as described in Section 4.6, these networks form the basis for a good deal of the innovation taking place in today's fresh produce industry.

4.2.1.1 Market and industry trends

How the fresh produce industry responds to changes in the wider marketplace was seen to be a critical component of innovation, particularly in terms of the economic drivers of change (see Section 4.4.1). Marked by a high degree of competitiveness at the retail and buying 'end', returns to growers were felt to be shrinking or at least stagnant:

"We need innovation to reduce costs because the price back to the grower is falling in real terms, and they need to be able to produce their vegetable and salad cheaper and cheaper each year." (12)

In turn, the industry is perceived to have consolidated into larger units striving for greater economies of scale to serve the needs of large retailers (through which most fresh produce in the UK is sold) in both *horizontal* terms – with firms buying firms producing similar products – and through *vertical integration* – with firms buying 'up and down' the supply chain to ensure greater control of supply.

Now characterized in certain sectors by very large, specialised, internationally-minded businesses that have control, in some cases, of close to one hundred percent of the market for specific products, the fresh produce industry has increasingly high costs/barriers of entry (to the market) and scales of investment required to maintain competitiveness:

"... [ability to invest is] the biggest one that stands in the way with all innovation I think. We're trying to build structures like this [signals outside greenhouse] they're half a million pound each. That's half a million pound there. I could do with another eight of those." (14)

"Well we've spent a million pounds on plastic on this farm. That's a big number. Somehow I've got to get that back. I didn't spend all of it, but I have got to keep spending to try and get it back, that's what I'm trying to do." [34]

In large part, these increasing economies of scale are driven by the needs of the larger UK multiple retailers – the *Big Four* – and, specifically, the competitiveness amongst these businesses, which manifests itself in "price wars". It is these "price wars" that have led to diminishing returns for the growers that supply retail markets, who, in some cases, felt that innovation was a "treadmill", in which:

"… most growers [are] running faster and faster and faster to try and stay in the same place…" (9)

Others suggested that this was the driving force behind "defensive innovation" in the industry, which is taken to mean innovation that reduces costs or improves efficiency, often framed against the threat of business failure:

"A lot of the innovation on farm that I see in fresh produce is borne about by necessity, because the farmer says "if I don't do this, I'm gonna go out of business". And that's not how you should be pushing innovation, but that's what I see." (29)

"And essentially, driven by the marketplace which is constantly providing product differentiation, the supermarkets are [unclear] each other- they all look the same, but of course they're always pushing each other forward… and

the view was from people- very senior people, elite leaders of large consolidated businesses in the industry, they were saying "yes that does drive innovation, but it's actually quite a defensive, quite a limited sort of innovation". So you probably do have less step-change." (31)

A notable feature of the industry is a shrinking repertoire of approved pest control products. This presented growers with a number of problems, though inasmuch as this acts as a barrier to innovation (see Section 4.7.1.4) it was also seen as a way of fostering more sustainable farming practices. Comparing the viewpoints of a large-scale producer of field vegetables:

"We've lost a huge percentage of our active ingredients in the last ten years. And because we're innovative and resilient we always find ways around the problems. I don't think we've actually stopped producing anything in this country because of that... yet. But I think, erm, we're probably not a million miles off. Something like onions for instance, if we lose any more herbicides it'll be virtually impossible to grow here." (1)

… and a small-holder selling through a local farm shop:

"Yeah I think it's great 'cos it encourages better farming practice. And also encourages innovation if you like, 'cos it makes it more difficult. I- the reason I'm still here is 'cos I expect nothing." (16)

… serves to highlight the range of attitudes towards this issue, though a clear similarity emerges: a pragmatic attitude towards change, which is common throughout the industry.

More and more tasks previously fulfilled by the public sector are now increasingly in the hands of private business and NGOs (or *left* to such organisations), with research and agronomy now being practiced entirely within the private sphere:

"I would expect [AHDB] to be here on my field doing proper commercial trials, and you know who we get here? Independent companies. I get phone call after phone call, independent companies want to trial their- ten metre square plots in the middle of our- commercial trial..." (14)

Others, however, felt that private businesses had not stepped into the 'gap' left by formerly public research and extension services:

"I suppose the government expected companies to pick it up, which they didn't really do." (30)

Today, the AHDB remains responsible for many of the functions previously undertaken by public research and extension services, and this is discussed in greater detail in Section 4.2.3.

Interestingly, the 2007/08 Financial Crisis and subsequent Recession[14] has had a lasting impact on the sector, with newer actors such as large retail "discounters" Aldi and Lidl gaining market share at the expense of the "Big

[14] A period of sustained economic contraction in the UK ran from Q2 2008 – Q2 2009 (15 months) according to the Office of National Statistics (ONS)

Four" (see Section 2.2). In response to this, the previously dominant multiple retailers have sought to: 1) control supply to a greater extent by taking over certain operations and 2) reduce the number of product lines they sell to diminish overhead costs and maximise stock of high-selling lines, in essence "copying" the discount model. This has the potential to shape the direction of innovation:

"… there is also quite a cost to the retailer of establishing the market for a new product and when they were making big margins and they were profitable they will have been prepared to take some of that pain of establishing a new product and waiting for the time for people to start seeing buying it and then repeat purchasing it, so I think we're also seeing as s side effect of the rise of the discounters that there is less choice in fresh produce in the big four…" (2)

It is clear that there is a perception that the commercial fresh produce industry is becoming increasingly consolidated into larger units, in part driven by the demands of the retail markets through which most produce is sold. As such innovation in this environment tends to be "defensive", focused towards maximizing profit in an intensely competitive environment. At the same time, a notable trend is the reduction of available pest control products, which threatens to drastically alter certain methods of production.

4.2.1.2 Scale and size of farm businesses

Strong emphasis was placed on the variation in the size and scale of farm businesses, which was seen to have led to or determined:

- *Divergent "research agendas"*
- *Ability to influence research direction*
- *Ability to communicate research needs*
- *Ability to fund in-house or collaborative research*
- *Access to and attitude towards science*
- *Attitude towards collaboration*

In an industry that is evidently becoming more and more consolidated, smaller growers, where they exist at all, are less able to put their research agenda forward either due to a lack of influence and/or communication, stemming from inadequate resources in time and money. Larger organisations are in a better position, both in terms of finance as well as human resources, to influence research agendas, and crucially, to be involved in research projects through joint-funding initiatives with, for example, the AHDB or through in-house research, engineering and farm-level experimentation. As one researcher put it:

"... so one project we've got, it's an [joint industry- levy-funded project] looking at field mapping and looking at precision farming... [company involved] can make that happen. If you went to one of the smaller businesses they couldn't use it. So there's some innovation that's only gonna work at scale and then there's other thing like innovation like IPM, or new breeding lines for example. They could be picked off the shelf by anybody. So there's a scale-dependent sort of response when it comes to innovation." (19)

A further, connected issue concerned farm businesses' openness to sharing knowledge, though this remains a somewhat "fuzzy" issue, with opposing viewpoints. On the one hand, it was suggested that larger firms, competing for market share with fewer but larger rivals, were disinclined to share anything that might give them a commercial advantage. However, in the absence of competition – or, vitally, in the case of *perceived* shared problems – the prospect of sharing knowledge was considered less problematic. In part, this appears to stem from the fact that it is difficult to *conceal* innovation:

"I think generally the big growers are happy to share their knowledge once they've got the competitive advantage, had it for a few years, and then it's- you know... it's very difficult to keep a secret in this industry…" (15)

However, there are differences not only *between* operations of different sizes and scales but *amongst* the various sectors that make up the industry.

4.2.1.3 Distinctiveness of fresh produce sectors

There is a high degree of specificity within the horticultural industry with regards to diverse crop types, growing methods and growing environments. A researcher in Wales, a nation with relatively little commercial horticulture, summed up these issues concisely:

"And of course a large carrot grower in Lincolnshire, or Lancashire, or a brassicas in Lincolnshire is going to be very different from somebody trying to grow things on an Aberystwyth coast." (18)

Importantly, this specificity is reinforced by certain institutional arrangements such as the levy board panel structure through which research funding is distributed; grouped by crop type, pooling funding across sectors remains challenging and reduces the ability of the levy board to fund 'larger' projects that might benefit swathes of the industry at once;

"Not everybody's been aware of it, quite often we might be developing technology that's applicable to a whole range of crops but one panel will be doing it, but the other panels are blind to it, they haven't shared their costs, and then they don't share the learnings." (31)

Distinctions such as relative production time-scales (a perennial apple or cherry tree, for instance, vs. a non-perennial cabbage), the relative market value of the various sectors, the diversity of growers within a sector and their characteristics were deemed to influence other factors, being:

- *The willingness to share knowledge*
- *Ability to 'self-fund' innovation*
- *Attitude towards change*

For example, the capacity for experimentation that is found in protected cropping – glasshouse and polytunnel systems – provides an ideal environment for testing new forms of control (as in other industrial settings). As one participant put it:

"I mean the horticulture system is also more amenable to manipulation in a sense, you put a glasshouse, you can control for every- so it's partly it's the kind of production system that is involved…" (3)

The move to substrate-planted, potted crops (grown in polytunnels) also permits a level of experimentation not seen in the field:

"We put some fields sometimes in at one density and at year two especially with raspberries we're altering the density… but certainly our systems- when we're in the substrate grow pots, it is just a unit you can move, you can change densities quite easily whereas when we're committed to the soil, we just have to go on a density that we know." [35]

As such, protected cropping systems were seen to be leading the way in terms of innovation. Likewise, there appeared to be a sectoral, rather than cross-industry, basis for innovation, with divergent interests when it comes to research priorities (or, perhaps importantly, the *perception* that interests are not shared).

4.2.2 Influence of retailers and others in the food supply chain

A number of supply chain actors were seen to shape the industry for better or worse depending on viewpoint. A major theme was the impact that retailers – and primarily the "Big Four" – had on the sector. Such observations were generally negative, though some lamented the tendency of producers to blame the retailers rather than examine where they might themselves improve their own businesses:

“I mean a classic example of how it's not working- on the way in I was having a conversation with somebody about a grower meeting that's been organised in one area, I won't say too much, and a meeting that essentially seems to be set up to complain about lack of money from the multiples, too much money being charged by the middle people and not enough money going back to the growers. So, it's essentially "everybody else has got to do something different so arguably we can continue to do the same thing" rather than "what are we going to do- what is it that's under our control that we could change that would affect our fortunes?".”

In the main, however, the sheer power of the retailers over their suppliers, and competitiveness with regards to each other, was seen to have led to several detrimental outcomes, including:

- *Increasing price pressure or even “price gouging”*
- *Scrutiny of grower innovation*
- *Squeezing profit margins in light of innovation*
- *Costs being “pushed up” the supply chain*
- *Restricting the scope of innovation (“defensive” innovation, see Section 4.4.1)*

Controversially, perhaps, the larger multiple retailers are able to wield such power due to there being, on the one hand, many more growers than customers – an *oligopsonic* market structure – and, on the other, what was seen to be an oversupply of produce driving the price downward. Some have concluded, therefore, that the number of primary producers is now too high:

"… [in] the industry there's just too many participants, so the supermarkets always have the upper hand because there is in general an oversupply rather than an undersupply…" (23)

Where retailers were supportive of innovation, this was seen to be mostly self-serving; retailer buying-behaviour is "at odds" with supporting innovation, in this view, because constant pressure on prices undercuts the ability of farm businesses to adequately re-invest in their operations (see Section 4.7.1.3).

However, multiple retailers are not the only actors influencing the industry. Government and other organisations – or "politics" as it was often referred to – can also shape aspects of the sector. The European Union (EU), for instance, received the blame for the withdrawal of certain pest control products but regional politics play a role as well:

"… rather than be led by public opinion, it was time that the Scottish government actually had the balls to stand up and shape public opinion. And lead public opinion rather than follow it… I mean it'll never happen 'cos we've got an election next May, which is why GM's [genetic modification] *a hot topic in Scotland just now... there is no basis in science for us opposing the ban. It is purely political." (22)*

The *consumer* holds significant sway over the functioning of the fresh produce market (the same being true for any market). How the consumer – and the value of treating the tastes and purchasing power of millions of people as one unit is questionable – interacts with and shapes the scope of innovation is beyond the scope of the present research.

4.2.3 The role of the levy board

As the organisation with the most direct responsibility for joint research and development projects within the fresh produce industry, the AHDB was a common topic of discussion with regards to innovation.

In general, interviewees reflected on the presumed role of the AHDB, focussing on this function and whether it was being achieved in current circumstances. It is possible to group these observations into two simple categories: *opportunities* and *weaknesses* (presented as a table below).

Table 8 The perceived opportunities and weaknesses of the horticultural levy board's operations

Perceived opportunities	Perceived weaknesses
Ability to “pull together” resources	Panel structure results in reactive, risk-averse, non-strategic thinking
Ability to slow rate of consolidation by sharing knowledge	Panel structure/sectoral funding regimes causes difficulty in pooling strategic funding
More strategic approach being fostered within the organisation	Re-branding of AHDB-funded research dilutes perceived impact
Businesses looks to the organisation for ‘generic’ solutions	Loss of expertise over time

	Large, bureaucratic organisation
	AHDB communication not aimed at an 'operational level'
	"Louder voices" dominate grower panels
	Reliance on voluntary engagement with panels

Many of the themes identified in Table 8 constitute barriers to innovation in their own right, and combine with other factors to impede innovation (discussed in Section 4.7).

It is clear that there are significant differences in attitudes as to the relative responsibility of the levy board and what that responsibility entails. A complex issue, embedded in the wider landscape of changing research and extension regimes, where one actor's responsibility ends – and another's begins – in commissioning, delivering and communicating the outcomes of research remains a contested area. In a rather uncontroversial manner, it was stressed that the levy board should focus on problems common to multiple sectors of the industry occupying "pre-competitive" space:

"… there's a lot of you know movement of funds between sectors, trying to get it fair… but actually a lot of the work they perhaps do, needs to- and are doing now with the soils project, is actually go back to basics and try and challenge some of the fundamentals common to everybody." (13)

"Yeah I mean the one area in horticulture where there is pretty much unanimous about it's all worthwhile and for the common good is crop

protection work, so we'll all lump some money in to make sure we've got the chemicals we need." (15)

However, some felt that the levy board had taken on tasks beyond this more explicit remit:

"… they have a function in life to manage and to support the research program, but what they actually seem to want to do is get embroiled in all sorts of other areas… extension work we don't want, spending [unclear] on organizing meetings which we don't want to have, pulling together packages which aren't necessary. Going to bloody- marketing, getting involved in marketing ventures and ideas, and is disruptive of the marketplace and is unhelpful…" (21)

That "louder", more influential voices were seen to dominate grower panels reflects the disparity in size and influence of fresh produce businesses, but this was perceived by some to be natural – or at least hard to avoid – and *just* in the sense that those who seek to influence the levy board research agenda deserve to receive the fruit of that effort:

"… you'll never please everyone. And if some people are more vocal and proactive, in terms of seeking research or promoting research, then it's fair that they should- I mean that is life isn't it?" (13)

However, if we acknowledge that the ability to influence this research agenda varies from business to business, and disproportionately favours larger businesses, we re-encounter the issue of scale (see Section 4.8.2.2).

Despite the perceived problems with the levy board's structure or operations, those involved in the organisation are aware of a number of these issues:

"So we're all failing to ask ourselves "how do we maximize innovation?" We're all saying "how do we spend this money?" or "how do we get our bit of that money that's being spent in order to keep our little bit of this thing going forward?" and we all hope that we do interesting things, but it's not really a recipe for driving innovation." (31)

It was also presumed that without an institution such as the levy board, the disparities in size would grow larger:

"If there was no HDB, now, erm, it's just- it would accelerate the big growers getting bigger." (15)

In summary, the role, capabilities and structural setup of the levy board was brought into question by many participants due to its position within the wider innovation system; its proper remit was challenged, but there is broad agreement as to 'safe space' for research.

4.2.5 Long- vs. short-term vision

An important distinction was made between, on the one hand, the ramifications of short-term thinking on the industry, and, on the other, the need for longer-term thinking. Such distinctions were manifested in three main issues:

- *Reactivity of levy board*
- *Need for foresight in R&D*
- *Sustainability*

As documented above, the panel structure of the levy board, whilst being the primary mechanism by which growers exert influence over the research process, leads to “reactive” or “responsive” – rather than strategic – decision-making. As one grower noted:

“The one problem with that is that the growers who sit on those panels they're thinking about today's problems: "what's my problems this year?", "what am I struggling with this year?" and not thinking about "what are my problems gonna be in ten years time?", and if you want to get into R&D and really deliver R&D, you need that horizon view.” (1)

Given some of the emergent challenges to the industry (see Section 4.10) foresight in research is considered vital. However, this issue is no secret and has been recognised by those at the levy board:

“… we're going to move away from this completely responsive mode we take the levy annually and we split it up between the sectors and then they've already got commitments so they've got what they've got left and then "what can we afford?"… we need a strategy- now there's going to be nothing magical about the strategy it's going to simply be a clear articulation of what

the longer-term challenges are, and then a framework so that we can take a serious look at what money we put onto the table for different challenges..." (7)

"... it's about trying to get people to lift their eyes to the horizon really, because most businesses seem to be very focussed on their day to day issues and getting over those, and the innovation, getting the innovation into that is something which is quite a difficult thing to do because they are very much taken up by their day to day concerns." (8)

So too is the long-term viability of UK farming threatened by short-term, monetary gain:

"The problem is all the best land is already in the system... and privately owned. And people are going to put a short-time gain of growing high value crops now, whilst the cereals and other crops aren't of any value. That's their main income, that's their cash crop." (13)

It is clear that there are voices calling for longer-term vision in the fresh produce industry, particularly with regards to research and development. However, as discussed in the next section, predicting the impacts of future innovation can be extremely challenging.

4.3 Innovation in fresh produce

A more explanatory category emerged with regards to innovation processes in the UK fresh produce industry, revolving around several connected themes:

1. Defining innovation
2. Observations about innovation
3. Types of innovation
4. Impact and measurement of innovation
5. Areas for future innovation

These themes are explored in more detail below.

4.3.1 Defining innovation

Some participants sought to clarify the meaning of innovation (whilst many did not) or exclude certain things from their definition of innovation.

For example, the director of a large farming business took a wide view of innovation:

"Anything you change, for the better, that's innovation." (1)

Others struggled with the notion of novelty, questioning whether something that was not 'new' or even created by the party implementing the technology or practice was innovating:

"… other sort of precision farming techniques have come in, say if you go to somewhere like [name of business] they're planting lettuce and the tractor is driving itself up and down the field, there's nobody on the tractor but there's plenty of people behind, checking the lettuces have actually been planted properly, but again this is applying technology which is already there it's not... I suppose you could argue it's providing an innovative way of using GPS-enabled technologies, but it's not sort of erm... it's not revolutionary." (9)

A question arises here: is something only innovative at the point of creation? Likewise, does innovation have to be "revolutionary"? It is possible of course, to capture value from something 'old':

"Now of course the innovation might be going back to an old variety so it's not necessarily something new. It's doing something that's different. That's what I understand as innovative." (15)

A further question concerns the contribution of science and whether this constitutes innovation in its own right:

"… yeah, so scientists have been a huge source of um..." [doesn't finish sentence] *(2)*

We also hear echoes of Kline & Rosenberg's (2000) observation that innovation is often conceived of as technology of the highly visible kind:

"I think it's really hard to define, 'cos it can mean different things and er I think probably what most people at a growing base mean by innovation, they mean new bit of equipment or something new that they can do." (19)

In summary, the definitions provided by participants of this project mirror the litany of ways and nuances used to describe the phenomena found in the literature outlined in Section 2.3.1.

4.3.2 Observations about innovation processes

A number of important observations of a general kind were made about innovation processes. For example, its importance was stressed in strong terms:

"Innovation as I see it is hugely important. It's a mainstay of our own business, and it needs to be the mainstay of any horticultural business." (11)

"Vital. Fundamental. Innovate or die." (27)

The importance of innovation for the industry was often invoked with reference to the competitiveness of the sector; keeping pace with ones' competitors is a key driver of change (see Section 4.4.1). The term "innovation treadmill" was used to describe this continuous process. Indeed, it was likewise observed that innovation leads to further innovation:

"… 'cos you get these breakthroughs and you get lots of secondary innovation, which can often be hugely significant. You know, but it's a follow-on from the

first thing. So if you put strawberries under covers, then you create all sorts of pest and disease challenges, you also make it easier to develop solutions and so the whole thing ramps on, you start to move new varieties forward erm... and yeah I mean it's absolutely, you know without that you just don't get to hold your market, because it is extremely competitive." (31)

As such, innovation causes further innovation to complement, or make viable, prior innovation. One participant described innovation as a "jigsaw" that forms a whole. Some participants described the impact of innovation elsewhere as "knock-on" effects – such as the increase in the price of straw due to the breeding of dwarf varieties in cereals resulting in less straw – best exemplified in the case of polytunnel usage and the changing pest/disease profile that has developed simultaneously. The evolutionary, incremental nature of innovation in fresh produce is reinforced directly:

"… often it's going to be incremental change and that means you're gonna move on from where you are, not going from having 20 hectares to 2000 hectares as a consequence of one step." (19)

A further factor here is what we might call "relative visibility", which refers to the differences, and relative value, of one 'type' of innovation over another with respect to how it is perceived by others. As one grower put it:

"… you can have innovation but innovation at our end is not necessarily gonna be something that's perceived as beneficial to the consumer." (22)

Compounding any efforts to change, innovation is a starkly unpredictable and uncertain process:

“... the reward to the innovator is very uncertain… it's easy for the people towards the end of the process to see how they get their award, but how is that initial innovation being awarded when only ten percent of the ideas might make it through?” (19)

“… ultimately you can run the scenarios but until something's actually physically happening and occurring, you know, certainly in fresh produce it's such a- today, now sort of industry you can have the best laid plans but they're constantly having to evolve.” (33)

Interestingly, though, this does not diminish, but perhaps enhances the need for, a plan:

“So obviously plans change all the time, that's what farming is, that's what any job is, but farming particularly, you make a plan and you change it. The real cock up in farming is to not have a plan.” [34]

One soft fruit business that had taken the decision to grow blueberries under polytunnels for the first time; although it is now not uncommon for soft fruit growers to use polytunnels in blueberry production (Scotland boasts the world’s most northerly blueberry producer thanks to such tunnels), this particular company, which is affiliated with a large UK producer organisation, felt that the time was right to transition from outdoor to indoor production. For this, a fairly detailed plan was outlined:

"… we're going to have a go, yes. We've gone for a later-cropping variety 'cos we want to avoid the glut of the European production and especially Poland. And so we're trying to come in late- we're trying to look at a crop that'll arrive in mid-August and crop into September for us. So we'll use varietal choice because we're part of the marketing group we have a choice of sort of a logo-branded variety that is only available to our members… it's already been tested and trialed and accepted by our customers… we'll use a north facing slope- north west facing slope to delay the field anyway naturally… these blueberries will go into hydroponics, so they'll be going into cocoa-fiber…" (35)

Yet before the blueberries had even been placed under the tunnels, the farm manager had found it necessary to adjust the precise components of the potted substrate used in their on-site nursery.

Not only does this represent an interesting source of innovation – on-farm experimentation (see Section 4.5) – it displays the continuous need for adaptation during innovation processes, even one for which a detailed plan is in place and where those involved have prior experience with potted fruit growing, polytunnel production and the particular crop in question. Such experience, however, should not be discounted (see Section 4.8.2.2).

4.3.3 Types of innovation

A number of 'types' of innovation emerged during analysis, which can be broken down into a loose typology:

1. Product innovation
2. Engineering, automation and infrastructure
3. Management
4. Marketing

4.3.3.1 Product innovation

Innovation in a particular product was the most commonly discussed 'type' of innovation, suggesting a good deal of attention is paid to the development of new products in the industry. In particular, varietal development was seen as the "life-blood" of the industry, reflecting the need for product differentiation (sometimes called "points of difference"):

"… you can reduce your cost of production in comparison with your competitors, or you have some sort of added value for the customer, whether that is longer shelf life, improved taste, improved texture... so sort of novelty product. It's some sort of provenance like organic. It's some sort of differentiation within the marketplace." (8)

Indeed, this appears to be true across all sectors of the fresh produce industry, from strawberry producers:

"Sonata's been the main... and especially in Scotland the Sonata- and that was really- although nobody was really able to put their finger on it what the difference was- just a better shape, better size and shape than El Santa…" (25)

… to carrot producers utilising an "old" product:

"The Chantenay [carrot variety] *was basically the reinvention of an old, good idea. The Chantenay carrot was originally grown for canning, because it fitted the can. But then canning went out of fashion, so Chantenay went out of fashion, and people used to say "oh I want a carrot that tasted like it used to taste"… but it needed a bit of refinement, it needed re-breeding." [1]*

The drive for new products was intimately associated with the needs of the retailer (i.e. those points of difference described above, such as shelf-life or improved taste). The drivers of innovation are dealt with in the next section. The importance of marketing in conjunction with varietal development was also stressed. As a potato grower and breeder noted:

"I think probably at the marketing end the biggest er innovation was really Rooster*, which made people become much more aware of individual varieties of potatoes…" (22)*

Innovation in marketing is considered below. New crop varieties may or may not require change at the agronomic level:

"I would say breeding's brilliant because you breed a new variety that's got disease resistance or pest resistance or better keeping quality and things like that… there's no added costs to growing it… your combine, your drill, things like that, everything- every bit of kit, other technology you've got works with that… you're not asking the farmer to change his- well, often you're not

asking the farmer to change his growing system, that's not one hundred percent true, so when F1 hybrid leeks were developed, so they were developed here, by my colleague [name] and when they were first released the farmers tried to grow them exactly the same way as they'd grown the old open-pollinated ones, and it was hopeless, they were useless, 'cos you had to change the spacing 'cos they were more uniform and things like that so there was some agronomy needed to do that but once that's worked out a new hybrid is grown exactly the same as the new hybrid. So when it's a- there are some more disruptive- there are some disruptive changes in terms of breeding…" (7)

Indeed, the fewer changes required of an innovation, the more easily it can be put into practice (see Section 4.8.4).

4.3.3.2 Automation, engineering and infrastructure

The automation of certain processes – and even whole operations – is an ever-growing area of innovation in the fresh produce industry. As a breeder pointed out:

"Automation is coming in right the way along the product handling line, so more and more we're seeing less people dealing with the product and it's all being done by conveyor belts, magic eyes, sorting equipment, bagging equipment, it's all automatic." (30)

Given the high labour costs associated with many fresh produce sectors, this is perhaps not surprising:

“Yeah well, for our business, er... the challenge is always trying to take the cost out of what we're doing, and one of the biggest percentages of costs are labour. So innovation around how we can reduce our reliance on labor and what we're doing out in the field and also within our packhouse as well.” (28)

However, engineering with respect to bespoke harvesting (and now packing) rigs, is not only reducing labour but ‘shortening’ the supply chain by consolidating tasks:

“… one of the most significant [innovations] is actually the move from packhouse operations to field-based packing where it's just taken out a whole stage of the supply chain and people and process associated with that...” (21)

Despite the encroachment of automation/mechanization across the industry, this is tempered in certain cases:

“There are some operations where you've got machines working hard and you need somebody there [unclear] a hundred percent of the time. Machines break down.” (14)

If we see the gradual substitution of human labour for mechanical processes as the continuing ‘industrialisation’ of the fresh produce industry, then this relies on ‘uniformity’ of crop to facilitate mechanised operations. As such, breeding programs and production systems have demanded uniformity as a means of facilitating control over production to ensure quality and efficiency:

"Erm... I think innovation in my lifetime has been about productivity and has been about large-scale. So the innovation has been going towards more more mechanized system that's giving more uniformity." (19)

This represents a dynamic link between different categories of innovation in order to achieve systemic change. As described in Section 4.2, there are increasingly high capital costs associated with the fresh produce industry. In part, this is due to the infrastructural requirements to produce and/or process horticultural products (at least in large-scale operations). Glasshouses, used in some salad production, for example, are prohibitively expensive:

"That's half a million pound there." (14)

It is the utilisation of *polytunnels*, however, which represents the most profound area of change over the last decades for many sectors of the fresh produce industry. The scale at which they are now routinely employed incurs considerable cost, not only in monetary terms but also in time and manpower demands:

"… to be honest now my preferred route is to have forty people and to wallop up forty tunnels in a day…" (34)

As an infrastructural innovation, polytunnels have spurned "secondary" innovation in the form of alternate pest and disease control, for instance:

"Yes, we say we're in control and we do find that it reduces our reliance on fungicides, not necessarily insecticides but it allows us to establish biocontrol products and use biocontrol fungicides, or actual releasing biocontrol products. Beneficials, that's the word." (35)

The greater degree of control offered by protected systems is discussed in Section 4.2.1.3.

4.3.3.3 Management and farming practices

Innovation associated with how operations are managed on-farm, was a further discernable category of innovation. This is in contrast to what we might call physical 'inventions' that often have greater relative visibility (as described above). Yet some consider new management practices innovative in and of themselves:

"Some of the innovation we have in the business is around how we manage our people, how we motivate our people, how we engage our people. That can drive massive productivity gains in its own right." (1)

Given the consolidation and specialisation being seen across the industry, some have suggested diversification is a key management innovation; indeed, one participant in the project had diversified away from large-scale single-crop production – due to not being able to compete with larger, consolidated businesses – to sell a variety of local produce through a farm shop, demonstrating the kinds of strategies that are available to growers. For one cherry grower, a significant expansion of operations brought with it new challenges, particularly around the 'skinning' in tunnels during a narrow window in the spring. A good deal of planning went into the management of labour resources during this time:

"… we went from the thirteen tunnels to seventy three. So if you want a good word, we had to innovate. We had to find a way to do more and to do it quicker. And I was talking to people like Haygrove who have sort of stats about putting up tunnels and taking them down, and they said er "in theory one man should be able to put up one tunnel a day"… and what I do now is I hire in- I get on contract twenty or twenty five people from another farm that has lots of strawberry tunnels. So I get them to come here to bolster our gang for the cherries. So that gives us basically we're aiming to have thirty five forty people on the farm four thirty in the morning for two days of the year to put the tunnels up." [34]

The use of biological control, as opposed to 'conventional' pesticide practices, is also an area of increasing interest, driven in part by the loss of active ingredients and greater control in protected environments, but also pesticide resistance in certain pests:

"… the reason why biological control is now widely used in glasshouses for pest management, tomatoes, cucumbers and so on, is because in the 1960s insecticide resistance was such a problem they had no alternative but to move into that- that mode of operation if you like. A lot of that work was done at what was then the Glasshouse Research Institute down at Littlehampton, which eventually became part of HRI." (9)

"So outdoor crops we would have sprayed more, we're almost adopting organic crop protection principles because we can under polytunnels, i.e. using biofungicides a lot, whereas outdoor we're getting weather events." [35]

Likewise, predictive models – which represent an important area of innovation in and of themselves – are routinely used to determine the expected pressure of a particular pest, supporting on-farm decision making; a parallel exists for those storing produce, with sensors providing real-time data on stored goods, allowing them to better control supply:

"So you then have these sensors throughout the store, and you can sense instantly if something is changing rather than waiting on a visual inspection, which may not be due for another three weeks, or a month, by which time- you know fifteen percent of your crop is gone…" (32)

Indeed, greater precision in large-scale commercial farming takes a number of forms:

"So the innovation that we've done around this area- I mean we've done other things like, for example, we were the first to start using variable rate-spacing on potato planting, using soil sampling of soil densities across the field and then variable spacing it." (27)

Of course, some kind of managerial decision normally precedes the adoption of any new practice or product, making management an important component of the innovation process.

4.3.3.4 Marketing

As noted above, marketing was considered important with regards to varietal development; it serves a key function in supporting other innovations, which, as described in Section 4.3.2, reflects the 'interconnected' nature of change. Marketing reinforces the differentiation sought after by retailers. Likewise, some suggest more could be done to advertise the industry's health credentials:

"There is no doubt that if you eat a diet that is rich in fruit and vegetables, it is better for you. And the industry as a whole from start to finish, needs to do more from an innovative perspective to get people to access fresh fruit and vegetables on a more regular basis across all the eating occasions in the day." (10)

A grower of ornamental plants in England expressed the power of marketing innovation in clear terms:

"… so the whole industry has changed quite dramatically over the last ten years from- if you go into a garden centre- the best analogy would be Waterstones bookshop. Right, so if you're not a regular garden centre visitor… the same thing's happened. If you go to Waterstones bookshop, around the walls is the A to Z and even sections of the walls now, they've turned into promotional areas, so that the walls are the A to Z, and the benches- the tables in the middle of the floor are the promotional, free-display areas… so they'd do the "summer collection", they'd do the "books to read in the winter" or stuff like that on the walls, and within the walls they'd

do "recommended by the management of the shop" or recommended by the staff- yeah, "we love because...", handwritten "we love because...". It's brilliant. Right so the same thing happened in garden centres. Garden centres used to be A to Z, so Abelias at one end and God knows what at the other- at the other end, and they- we started- it was actually driven by the suppliers in that the suppliers first went out there and said "look rather than putting this - in our case it was a Hebe called Rosie - rather than putting Hebe Rosie in the H section of the plant area, why don't you just put them on a bench, and we'll sell you fifty of the them, not the ten that you would normally have, about fifty of them. Put them all on there and they'll sell... far better than any of your other Hebes because we've put a bespoke label in there, we've got a pink pot, we've got a poster for you. Whole thing. That's what they did. So they agreed, they said yes, and it worked." (17)

It is clear that marketing innovation at one 'end' of the supply chain can have impacts upon other parts of the supply chain, and that the source of a given innovation – as in the case highlighted above – may be product of interaction *between* these different parts (see Section 4.5). Of course, there are also new ways in which people *purchase* produce. As a participant representing a UK retailer noted:

I think with internet shopping and how people engage with buying food- these sorts of innovations change and think ten years ago the idea of having your food delivered to your home, and not having to go out… so how do you create innovation to a customer that's shopping on a tablet rather than coming into your shop…? (33)

Quite how this impacts upon other parts of the supply chain – other than offering the potential to boost sales – is not precisely clear, but does represent innovation at the ‘end’ of this chain and should not be ignored.

In summary, although we can categorise innovations into a loose typology, what becomes apparent is the co-dependent nature of innovation (or perhaps “innovations”). They are not always discrete products, but larger processes of change. The use of polytunnels in successful cherry growing, for instance, required numerous follow-on innovations around human resource management, learning activities and invention.

4.3.4 Impact and measurement of innovation

The outcomes and measurement of change within and across the categories of innovation described above form an important theme in the data. Such observations were often made with a specific innovation, or suite of innovations, in mind. For example, a potato grower pointed out the benefits of precision farming techniques (such as GPS monitoring to facilitate field mapping and variable spacing during planting):

“It's allowed us to produce a much more consistent high-quality crop than in the past. It's helped us reduce the numbers and scale of the problems that crop up in farming.” (27)

Of course, the impact of using polytunnels in soft (and now stone) fruit production has been dramatic, both in terms of increased output and, as one agronomist noted, extension of the growing season:

"So you know they can potentially crop from May through to October... if you go back twenty years, twenty five years, the strawberry season was- early varieties in mid-May, through the late varieties into mid-July." (15)

How we might feasibly *measure* impact is considered a complex and difficult issue:

"… that's the most difficult thing in the world to do." (6)

However, the difficulty in assessing the impacts of innovation appears to depend on the 'type' we are interested in examining. For example:

"… in the case where we're saying apply less nitrogen or sometimes apply more nitrogen, then you can say well, you basically saved the cost of fertilizer if there's no effect on yield so you can actually make a financial case." (6)

Yet the task becomes more challenging when considering the interlinked nature of innovation, which may rely on 'separate' innovations from a number of different areas to instigate wider technical or social change. Given the AHDB's role in funding relevant research for the industry, the notion of impact and its measurement is of practical concern. As one participant suggested:

"That for us always has been the ten million dollar question. I think if you go to talk to people in similar positions elsewhere in the world they have exactly the same problem… it's a complicated area, I think it's partly about scale, so

at what scale are we trying to measure this impact? So if you take one particular piece of work focussing on one particular issue you could argue "well we found a solution to a pest or a disease or whatever" and then how do we show that growers have actually taken that technology and used it. At very simple level you could look at pesticide statistics and see if that particular product has been taken up or whatever... doesn't necessarily prove anything. You can talk to growers and ask them if they've done anything with it and we do try and do that sort of thing. On the other hand you could scale it up and say OK, we do programs of work which cover crop protection, horticulture in general, how do we measure the impact of that?" (9)

Others noted that the use of *narrative* (i.e. personal accounts of change) were useful in explaining impact to funding bodies for instance. The director of a project aimed at bolstering horticultural innovation suggested this was useful:

"… And in fact we use narrative really I suppose as much as anything to investigate the success- we have feedback forms from each event, people put the comments on and they will say things like they didn't like the lunch much, things like that. But they'll also say "I've never thought of that before it was really good" or "I brought a friend because they happened to be staying with me and they were able to tell me much more about this" and so on. So you get much more from narrative than you do from metrics." (18)

Given what has already been said regarding the unpredictable nature of innovation and that measuring the impact of innovation can be so challenging, it is interesting to observe that certain actors, especially researchers, are routinely asked to 'predict' the impact of their work on the wider world:

... this is a problem with funding bodies 'cos they always want to know what the benefits are of what they've put into research and they also want you to predict it ***before*** [author's emphasis] *they start the research... so you make things up usually. (6)*

Ultimately, very little in the way of practical, proven techniques for measuring the impact of innovation were forthcoming (see Chapter 5).

4.4 Drivers of change

What drives innovation in the fresh produce industry? An emergent category was derived from, in part, direct answers to this question *and* responses from participants made during the course of the interviews as to what encouraged people to change. Three sub-themes emerged:

1. Economic drivers
2. Retail needs
3. Regulatory drivers

Each of these categories is explored in more detail below.

4.4.1 Economic drivers

One participant was able to sum up the driving forces behind innovation in the fresh produce industry rather succinctly:

"So I think there's really only two things that'll make growers really change, sit up and change their minds, one is: that it's going to make them some money or it's going to save them some money… and the other one really is it's going to continue to give them a license to operate, and by that I mean it enables them to overcome legislative hurdles if you like…" (9)

Given the competitive nature of the industry, and what might be described as the oligopsonic structure of the UK fresh produce industry, it is unsurprising that change is largely driven by economic incentive; as such, much has been done in the name of improved efficiency:

"… the history of fresh produce in the UK has been aggregation, bigger and bigger or cooperatives as well which has all been driven by need for efficiency and cutting costs." (7)

Staying 'one step ahead' – of competitors – is important, but such competition is not only domestic:

"… one of the things that's driving the success of the soft fruit sector, is a big improvement in imported produce, so people are eating more berries because the standard of berries that they're importing has gone up significantly, and so berries is becoming completely a twelve month of the year thing…" (32)

The increasingly high cost of labour for produce businesses is driving the push towards greater automation and reduced costs:

"You've never really stood still, and I think the main driver for that is labour. You know 'cos labour costs are constantly moving…" (25)

"I mean we have to get our harvesting- unit cost of harvesting down, which we're constantly trying to do, and to be able replace the human being or at least assist the human being in more efficient work must be an aim." (11)

However, a downside of the constant search for innovation to remain competitive is that it has led to "defensive" innovation (i.e. reducing cost or improving efficiency) that some participants felt limited the capacity of the industry to affect 'revolutionary' or 'disruptive' changes. As one participant noted:

"A lot of the innovation on farm that I see in fresh produce is borne about by necessity, because the farmer says "if I don't do this, I'm gonna go out of business". And that's not how you should be pushing innovation, but that's what I see." (29)

Of vital importance to fresh produce are *quality* and *control*. Innovation, 'defensive' or otherwise, is often carried out in the name of either ensuring that the quality of produce is maintained or enhanced, and for greater control over the growing environment:

"So for instance on of the projects which we're doing is looking at novel weed control systems… we currently have a massive problem with weed control in our crops where the alternative is hand weeding, which is expensive and difficult to do. So there's a big opportunity if we can come up with solutions

to that there's a significant commercial driver within our business to make that happen." (21)

"… [blueberries & blackberries have] got a high-sale point so for the economics of covering them mean that we can assure the timing of the harvest. And we can assure the quality a lot, lot easier. It's within our- more of our control than having a weather event." (35)

The quality standards seen in today's fresh produce industry are in large part driven by the needs of the retailers through which most produce passes.

4.4.2 Retail needs

A related category of 'driver' stems from the demands of large retailers. Many of these can be linked to those economic factors described above:

"… it's this constant battle with the retailers who are constantly pushing down on price, constantly looking for more efficiency, scrutinizing the level of profit you are making out of them." (9)

Certain 'tasks', such as packing and labeling, have been pushed 'up' the supply chain by retailers, which has resulted in producers, processors and even breeders having to develop solutions to these processes:

"… they have pushed a lot of their operation down onto the growers… the whole head lettuce was being harvesting, and pack- trimmed and packaged in the field… no longer being done in a pack-house, no longer bei- labels and

everything, not being labelled by [retailer] or anything like that, they pushed it all down and said "this is your function", and so the innovation had to come because the grower's having to do some of the... processes that were previously done by the next person in the chain." (7)

"Oh yeah, absolutely it's all about saving money and if you can push part of your responsibility... the technical team that I work for has… halved in the time- in the last twelve months, as more and more has pushed back on the suppliers to actually do…" (29)

The drive for quality also appears to originate or at least be maintained by retailer buying standards:

"… we've been working with probably a few more suppliers and businesses to give us that confidence that you're going to have that availability at the right quality 'cos you can't just sort of- ultimately we're a [high-end retailer] and you've got to make sure your sourcing strategy enables you to get the very best quality product you can." (33)

It also apparent that retailers play a significant role in 'challenging' others to innovate, discussed in Section 4.8.1.

4.4.3 Regulation

A further driver of change is regulation. Those involved in the industry must conform to regulation governing various aspects of land management and food production. In this sense, change is obligatory, but not necessarily easy.

For example, increases in the National Minimum and Living Wages was considered burdensome from the growers' perspective, as labour costs already represent a large share of costs. Such regulation may force produce businesses to adopt new practices or technologies (or risk harm to profits – see Discussion):

"… at the moment one of the big areas is the living wage and as good as it is and a good idea as it is, we're never gonna get that money back out of the UK marketplace…" (26)

"… they're thinking of hiking the hourly minimum wage from £6.50 to £7.30. That's massive, and companies out there are not going to be able to stomach it, a lot of companies. They just won't be able to do it. So that will make innovation even more important." (14)

Likewise, the loss of certain pest control products (a result of regulation) presented growers in particular with agronomic challenges. As a researcher discussing the loss of crop protection products pointed out:

"… that will have a huge impact and that's why thing[s] like agro-ecological integrated pest-management is now coming back on the radar…" (7)

Interestingly, regulation is also cast as a *barrier* to innovation (see Section 4.7.1.4). In the same vein, retailers have a role to play in supporting their suppliers with regards to regulation or certification:

"... it's trying to convince everybody that we're not trying to push everybody towards organic- but integrated pest management, it does include synthetic chemicals appropriately and targeted, a lot more monitoring, certainly from my own perspective, I have adjusted the specifications of a lot of the products we have to include not just on our specifications, which will be red amber green as to whether they're excepted by depots, to actually differentiate between beneficial insects and pests." (29)

Support for innovation – and the forms it takes – is discussed in more detail in Section 4.8.1.

4.5 Sources of innovation

'Where' innovation originates in the industry is one of the main research questions of this project. Interestingly, its sources are diverse but also non-discrete; learning by doing, for example, is a clear source of innovation, although more traditional ventures at private firms and research organisations are also nominal sources of innovation. However, it was innovation from other countries that was most commonly cited.

4.5.1 Overseas sources of innovation

Innovation in the UK fresh produce industry is often inspired – or directly 'imported' – from abroad, a process that is facilitated by several factors (study tours, UK-based firms having production sites overseas and strategic alliances between domestic and international firms). The Netherlands, in particular, is the source of many horticultural innovations:

“… there's go-to places from a plant perspective and from a technology perspective and so it's generally Holland…” (17)

“… if you want to see innovation- you probably want to go to Holland to see how all that works, to see how they are so successful with their innovation, 'cos that's where a lot of it comes from isn't it?” (27)

“… late 1980s, early 1990s, the in-thing were multi-row beds for apples so planting bed of eight, then an alleyway and another bed of eight etc. And it was copying and innovation that the Dutch growers had gone down. That was- we were doing it just as they were pulling all theirs out 'cos they decided it didn't work very well.” (15)

However, other participants described trips to the United States, Canada and Australia as being both personally formative and a source of new ideas, some of which were later implemented at home:

“When I was twenty-one I travelled the world, as a young farmer, farming my way 'round Australia and America. Erm, and I found a machine called a hydro-cooler, which was basically using very large volumes of very cold water flowing over a carrot crop to take the field-heat out, to give it shelf life... and nobody'd ever heard of them in the UK, so when I got home, my old chap said 'right you're in charge of carrots now', twenty-one years old, in a tin shed in the middle of [location] and I bought a hydro-cooler, and it cost £55,000, and we didn't have £55,000... I sort of ordered it without asking him [laughs]. But this machine completely revolutioni- has, completely

revolutionized carrot production since the late 1980s, so... within three years if you didn't have one you weren't in the carrot industry anymore." (1)

"The board of directors gave me money several years ago to go- I had this dream of- I had heard of a scheme in Australia on a cancer-fighting broccoli, they allowed me to go and invest in it, here I am some seven years later still working on the project… but it's all innovation, new varieties, new harvesting techniques, we were in Tasmania looking at new automatic harvesting machines, I'm going to Denmark in two weeks time looking at an automatic harvesting machine…" (26)

"Strategic alliances" between domestic and overseas firms also the spread of certain novel genetic resources (see Section 4.6.1.1).

4.5.2 Learning by doing

As observed in the previous section, direct experience with new ideas abroad is a common means by which innovation is brought to the UK. Such instances of learning are perceived as important amongst a range of literatures associated with innovation (i.e. AKIS and FSR). Experimentation and adaptation of innovation was the most commonly cited of these (often informal) learning processes:

"… if you give me something that my customer wants and it has certain problems associated with it, in terms of growing problems, I will find a way of growing it for my customer." (28)

“So that was a high-end retailer that was still looking for [hand-harvested sprouts]. They perceived that hand-harvested sprouts were still better quality than mechanical-harvest... but then we did some trials and proved otherwise.” (11)

“So it's three to four thousand pounds a hectare. To skin it and un-skin it [polytunnel]. Now that is high against the rest of the industry. I think people would think they could probably do it for under two grand. We really do it properly here. We've learned- this is a very windy spot here. The sea is about five miles away. I think just experience has taught us. We ask people.” (34)

Although some claimed that the drive to experiment was ‘innate’ in growers – and, indeed, there are many examples of on-farm experimentation and adaptation – people in the industry often rely on a network of support to achieve their aims (this is discussed in detail in Section 4.6.1). However, innovative thinking is not limited to the growers themselves:

“So, a lot of our work process innovation, a lot of our performance improvement innovation, has come from the shop floor… the supervisor came in one day 'nd said: "they don't half change them tires quick on the Formula One car, don't they? Everybody's got a job. I want to try it with my team". So he trained his team up, so that when they changed the film then somebody was doing something, and somebody was putting the hubs in, and someone was changing the print, and they got the time down to about five minutes. And that saved about ten hours of running time on a team of eight people every week- every day. Every day.” (1)

“… we'll get a new rig built and [the operatives]’ll say "you know wouldn't it have been better if this had been done?”” (26)

“They're quite good [workers] they come to me with ideas. They often come to me with ideas and say [name] can we try this and almost always I say "yes" even if I know it's not going to work. 'cos you always learn something. And if that's what they want to do you tend to not stand in their way, let them get on with it.” [34]

A clear example of on-farm innovation is found in the case of the Kent-based cherry producer intent on improving the efficiency with which polytunnels were ‘skinned’ in the springtime. As an intensely physical task, often involving elevated work, the farm manager and welder designed and built a special forklift rig to provide a suitable platform for workers to pull the plastic over the tunnel frame safely and quickly (see Figure 8).

Figure 6 In-house polytunnel forklift rig to aid tunnel 'skinning'

Of course, this represents perhaps one of the simplest forms of on-farm invention; some fresh produce businesses are now designing and building bespoke harvesting rigs involving considerable investment (discussed below).

4.5.3 Individual businesses and organisations

Certain organisations – private businesses in particular – were also considered key sources of innovation. The larger, well-known fresh produce businesses, for example, are capable of undertaking significant projects in-house:

"… because [company] have their own workshop to produce their own harvesting rigs and so on, they do it themselves. They actually manufacture

their own machines. They're in a sector that's so narrow no one else does it, and they do that with their own kit." (8)

"... [private businesses are] doing their own projects, and there's probably as much if not more going on funded by the industry itself and kept to the individuals for their own businesses, which... accounts for a good deal of innovation." (12)

Likewise, some international firms are held in high regard:

"They're the ones doing all the research. The likes of [company name] for example." (14)

One participant noted that non-governmental organisations, such as food associations also have a role to play:

"... so the Chilled Food Association is somebody who will communicate back to researchers what it is that is required by industry... they come into play in areas of innovation in relation to food safety." (2)

However, it is the various forms of industry conglomeration, such as grower groups, more formal producer organisations and marketing desk arrangements that provide both a channel for innovation (see Section 4.6.1.2) and a source of new ideas, novel plant material and access to funding:

"… the genetics and [unclear] plant type, that comes through the producer organisation, so our group get a- we're locked onto the Driscol brand so that's what we're onto. We're obviously- we've got the access to the P.O. funding to help us improve… whether that's improving irrigation improving tunnels, machinery, sprayer technology pack house technology, so many many improvements that we do undertake as a business because of the P.O. and the drawing down of the funding from Europe." [35]

The role of producer organisations and other groups is discussed in more detail in Section 4.6.1.

4.5.4 Formal research

The role of formal research, often coordinated by the levy organisations and UK research councils at the applied and basic stages respectively, is a further source of innovation:

"I mean, people who are "oh I've got nothing out the HDC", if I walked them round their farm and pointed out "well where did that come from?" or "where did that come from?", "where'd that come from?", half of them'd be from the HDC…" (1)

"Yes, but you see what we haven't done is talked about the scientists and there are some scientists who have made major and significant contributions over the years." (2)

Formalised research supports numerous parts of the industry, but it is in the realm of pest control, data collection, efficacy testing and 'cultural' practices that formalised, levy-funded research appears to make the most impact:

"I mean they've been very helpful in relation to the Suzuki Fly. Yeah SWD." [34]

"The cherry crops... the growers are monitoring hard and you'll see the work with the AHDB there's been some excellent projects done by then to try and improve control strategies... and the research going into it." [35]

Given the fact that knowledge can move relatively freely in the fresh produce industry (see Section 4.6.1.1) the origins of a certain innovation can be 'masked':

"… we have a strong grouping 'round here called Scottish Agronomy, who do trials and advice on cereals particularly oats and potatoes and I dare say we tackle other crops as well. But... [name] will be at every Potato Council event gleaning his overall knowledge... yeah, but by the time it goes to the grower it's not carrying an AHDB brand it's carrying a Scottish Agronomy brand." (22)

Formal research is often operationalised through specific research programs. If we consider the output of research as a key component in innovation, then how these programs are developed and, indeed, how innovation is supported in the industry in general is important, and the topic of the next section.

4.6 Communication in the fresh produce industry

This category concerns how the various actors that make up the UK fresh produce industry interact with regards to innovation. It can be further divided into two sub-categories – *positive interfaces & successful brokerage*, and *problematic areas* – that establish the basis for positive and negative approaches to innovation (more specific enabling and disabling factors are described in the next section).

4.6.1 Positive interfaces and successful brokerage

This sub-category concerns the interactions (interfaces) and activities that facilitate the innovation process between different actors (brokerage). It is further sub-divided into three parts, being:

1. Networks
2. The role of different actors
3. Specific projects

Each of these is described in more detail below.

4.6.1.1 Networks

The apparent importance of personal and professional networks to the innovation process in the UK fresh produce industry cannot be overstated; this was a recurrent theme throughout the data:

“I mean go direct to [research institute] because as I say we do have the close contacts with the scientists there, sort of say "what do you know about this? What can you do about it?"” (23)

“So that means that people's networks and people's... I suppose working relationships, mean that there are a lot of collaborations that have just occurred over experience, time and just... relationships with how people have been working. I can't really comment whether it's any greater or less in other sectors, but... certainly it's significant and been very beneficial, and I think we've seen more consolidation- everyone's seen more consolidation in the sector so there are fewer and fewer, bigger more significant, more professional businesses, I don't see that changing…” (33)

“I mean for us we have- the bulk of our innovation will come from a small number of people who we have personal trusting relationships with… So we work very closely with them and we value what they have to say for themselves and so we actually will follow their lead.” (21)

“I actually try and make a point of going to open days or dinners or whatever, not because I want to do anything else other than meet people… industry networking is very important.” (26)

These examples demonstrate that actors within the industry have a ‘support network’ they can utilise to meet their needs. As one participant advised: “know what you know, know what you don't know, and know someone that does know”. Such networks now commonly extend beyond the UK, sometimes in the form of “strategic alliances” between domestic and international companies:

“We have links with a Dutch company…” (30)

“No the seed has been developed by a big company, a big multinational company who we have a strategic alliance with and so yeah, they were trialling it in the fields and such thing. But as a research and development mission we actually have an alliance with a Spanish company and we actually used the Spanish- the Spanish winters are very similar to the Scottish autumns, so we actually get two years in one.” (26)

Personal and professional networks and strategic alliances offer a platform for the exchange of knowledge. The importance of personal networks was striking when it came to scientific research:

“Our main benefit from them is keeping in touch with the scientists so that er if they are coming up with ideas, and you know just…” (23)

“… some researchers are better keyed in to the industry than others, or better known by agronomists, we know they're doing that piece of work, we can pick the phone up and say "can you tell us a bit more about it? You gave us a presentation, can I- I'd like to have a chat with you about it”” (15)

Likewise, *grower groups* provide a platform for knowledge sharing, innovation brokerage and other functions, such as research agenda-setting (depending on the group in question). Grower groups take on various forms, from crop-specific peer groups (such as levy board technical committees) to retailer-specific grower groups. These groups are an important conduit of innovation and knowledge, and give growers an interface with other organisations:

"I'm probably fortunate that I've been part of R&D committees, I get to see a lot of proposals coming through and seeing what people are looking at on the research side, and trying to make them practical on how they can be applied on the field side…" (28)

The more formalised *producer* organisations play a major role in facilitating the spread of innovation and knowledge (see next section).

4.6.1.2 The role of different organisations and actors

Producer organisations, here taken to mean those organisations that have individual grower members but act as one enterprise (such as grower co-operatives or "marketing desks"), are important entities in the fresh produce industry. As noted, these act as a platform for sharing knowledge and innovation:

"… we [producer organisation] developed [technology] in-house and we use it, every single one of our growers uses it…" (26)

"… [we] probably have ideas, that are the same as like-minded people in the group and I think if you were on your own it would come to a- you would stagnate and come to a halt. Whereas you know you can sort of link up with

ideas and bounce off each other and- or it ends up mixed up a bit and out of it all the right idea comes out…" (25)

"So we'll use varietal choice because we're part of the marketing group we have a choice of sort of a logo-branded variety that is only available to our members… it's already been tested and trialled and accepted by our customers. So that's a good advantage." [35]

These organisations facilitate the spread of new ideas by using internal agronomy teams. Study tours are also organised by producer groups:

"… I mean [producer organisation] have had them to Mexico, to Chile, Argentina, the States, obviously and Spain and Holland…" (23)

Yet belonging to such organisation may lock 'out' as much as they keep 'in'. As one grower claimed:

"I suppose and that's probably a bad thing I suppose as far as innovation is concerned in the industry. Is- is the way that people are becoming very focussed into their groups. You lock yourself out of other things... or- well, locked in or locked out. But you know it was governmental bodies that were all to do with that in the past, so it was open to everybody. Whereas now if you have a good idea you keep it to yourself or keep it in the group you know?" (25)

Being part of such groups can drastically help reduce the inherent uncertainty of innovation. Take for instance the confidence with which one farm manager, belonging to a producer organisation with its own strategic alliances and access to proprietorial genetic material, can approach the task of putting a formerly outdoor crop under polytunnels:

"...we have a field of blueberries that are outdoor... it's only a little patch but it got us going and we've had them in the ground for ten years but we know that we'll get much better results with the new genetics and indoors and in grow pots." [35]

These organisations often host their own in-house conferences, aimed at transferring knowledge – including market trends, agronomy and technology – between members of their growing base.

Other, specific organisations and actors provide platforms for interaction and, importantly, brokerage functions such as translation/adaptation of scientific research. The AHDB, for example, acts as both a node for wider communication and as a translator of scientific research. However, as will be shown in Section 4.7.1, this lacks a substantial, formalised process. The Horticultural Innovation Partnership (HIP), also serves a similar role and the 'independence' (i.e. nonpartisan) of both the HIP and AHDB was considered to foster trust, which is an important factor for successful working relationships (see Section 4.8.3).

The importance of agronomists in this respect is also clear:

"... got to look at who are the influencers of growers' behavior, and agronomists are key influences on farms. And that's- if you want to get

growers to do something, you got to persuade the people who advise them to say "you should be doing this" or at very least looking at this…" (15)

"I [agronomist] *read the arable ones 'cos there's always something- they're always talking about blackgrass control in wheat, which you think "is that actually really important?" but actually it's becoming really important in vegetables as well, 'cos we can't control the blackgrass, we need some work on blackgrass control. So I'm interested now in what's going on in the arable sector, and see if there's any ability to transfer things from the arable sector into veg. We're in the veg. sector very much crumbs off the table of the arable sector in terms of crop protection." (12)*

"I'm a farm agronomist so for me [AHDB communications are] fantastic, it's right up to date. And then we can then use all that- but there's also other research that they're doing in other crops, so whether that's heating, use of biomass boilers it's lovely to have that knowledge and that understanding." [35]

In summary, there are a number of organisations that, in conjunction with agronomists, serve as vital conduits for knowledge.

4.6.1.3 Specific projects

A number of current and past projects were noted as being particularly useful in providing a platform for innovation. The Hort-LINK scheme (ended 2009) was successful at 'pulling through' research for example:

"… what it was doing was giving a vehicle for what had been funded in terms of blue sky... to get that carry-through to the market place and that it didn't get lost…" (2)

"I suppose the LINK schemes were the nearest we had to doing that, to enable some of that new thinking to be pulled through into that sort of applied thinking loop." (9)

One participant reported that the establishment of a new platform, the HAPI (Horticulture and Potato Initiative) project, is filling the 'gap' left by the termination of the Hort-LINK scheme. The UK-wide "Agri-tech Strategy" was also considered to be filling a gap in the provision for the translation of scientific research into operational forms:

"Agri-tech strategy and the Catalyst, has gone some way to fill that gap and certainly in terms of the amount of money that's available…" (2)

However, others felt that the Agri-tech Strategy was not sufficient to bridge the gap left behind by the privatisation of the previously public national extension service:

"… Agri-tech's great, but it's a hundred and sixty million quid, it's a drop in the ocean to be quite frank. You know, we got rid of ADAS, the big gap is the translation of research into practice... the extension. That's still a massive blackhole." (1)

The use of specific projects as ‘innovation platforms’ is discussed in more detail in the Discussion (Chapter 5).

4.6.2 Barriers to effective communication and collaboration

Several issues hamper effective communication and collaboration in the industry. As previously noted, what we might call the inherent competitiveness of the fresh produce industry prevents certain knowledge being shared and also prevents possible collaboration. At the same time, demand articulation (the ability to clearly express requirements) was cited as a problem:

“So I think- it's a term that's overused now, there's sort of er- making sure needs are articulated.” (9)

“… often people will talk about it- there is a problem sometimes in terms of the specifics, so often growers will say they have a problem in quite general terms, but they don't understand the specific reasons why they've got that so you have to actually then go in and tease apart the reasoning of why they've got that problem.” (7)

A reluctance to share other kinds of information was also apparent. One participant dubbed the reluctance of suppliers to inform their customers of the problems they face “positive spin”. Another demonstrated that it could sometimes be best to avoid discussing innovation:

"… so let's say you innovate to reduce cost... what we will tend to do sometimes we won't actually discuses that, 'cos the minute you say to somebody "right I've done this innovation you know it's reduced my supply costs by two percent" they say "that's fine, I'll drop the price by two percent". 'cos they don't understand about- you know you've taken a risk made all that investment, you should get the whole of that two percent back, they see that as an opportunity to make it two percent cheaper." (21)

Other issues raised concerned the relative lack of fora for communication (such as national conferences) and the "drying up" of traditional extension regimes:

"… since the demise of ADAS that translation of knowledge through to growers has dried up quite significantly." (32)

The loss of a public extension service is at the heart of many of the systemic barriers identified as 'bottlenecks' in Section 4.7.

4.7 Industry 'bottlenecks'

Several interview questions probed the 'barriers' to innovation in the fresh produce industry. Such questioning yielded a large amount of data, and has two main categories: *systemic* and *personal barriers*.

4.7.1 Systemic barriers

Systemic barriers refer to factors that "… negatively influence the direction and speed of innovation processes and impede the development and functioning of innovation systems" (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a) . Where the literature refers to 'blocking mechanisms' and 'systemic problems' or 'failures', it general indicates an issue of this nature (Lamprinopoulou et al., 2012, p. 4). Some barriers are "personal", belonging to the individual. These are discussed in the next section.

The systemic barriers identified in this project can be further divided into five connected themes:

1. Fragmentation
2. Formalised research
3. Economic factors
4. Regulatory constraints
5. Culture

Each of these is discussed in more detail below.

4.7.1.1 Fragmentation

Fragmentation refers to the weakening of structural conditions that enable actors to effectively communicate or collaborate. It takes two forms: vertical and horizontal. Vertical fragmentation denotes the lack of *hierarchical* communication and coordination from the government down. Horizontal fragmentation refers to a lack of communication between actors of the same type. We see examples of both vertical and horizontal fragmentation in the UK fresh produce industry, exemplified by complaints about governmental coordination on the one hand, and the lack of collaboration between private, competitive businesses on the other:

"I would say that [fragmentation is] something I feel, erm it's hard to substantiate." (10)

"Yeah there's different levels that's just not connected at all." (13)

"… the research in the UK is too disjointed. Having come from the AHDB model where we've got all the Agri-techs, and the HIPS, you know the NIABs, and the- erm, AHDB and everybody's sort of doing their own thing, and there's nothing actually coordinating it." (29)

"It's not a barrier to innovation inasmuch as if the individual companies fund work and it provides them with you know what they want then that's innovation. I think what it does do is cause fragmentation, so you might find the same things being done in a slightly different way twice or three times or whatever." (9)

"I don't necessarily see [things] getting more open. If anything things are getting more closed, and... there's collaboration within the partners, but outside the partners I suppose there are more brick walls, which makes it quite hard at an overall sector level but I kind of- I don't see it getting any other way at the moment." (33)

Fragmentation – and its effects – was commonly discussed in relation to knowledge, particularly *knowledge flows* in a post-public extension service environment. A combination of factors already identified, such as communication barriers between people of different specialisms, demand articulation and industry competitiveness, and the natural diversity found within horticultural crop types, serve to compound this issue:

"We've fragmented definitely on sector lines in fresh produce, we're so different to say the cereals, or say potatoes, 'cos potatoes- yeah, so it's naturally fragmented anyway and what you then get is you get a situation where because in fresh produce the requirements are so different between growing a tomato and growing lettuce for example, and growing a runner bean, totally different technical requirements means that actually the challenge is how do you share stuff between them." (19)

Fragmentation appears to be at least part of the 'translation problem':

"You know, we got rid of ADAS, the big gap is the translation of research into practice... the extension. That's still a massive blackhole." (1)

"… so we haven't got the join-up with the basic science anymore, into the applied science, in the applied science you've got all the contractors separated from each other, and the pull-through doesn't look terrible brilliant." (31)

Indeed, the functioning of formal research in the fresh produce innovation system also came under scrutiny.

4.7.1.2 Formal research

Several barriers to innovation are found within formal research structures. Aside from the privatisation of previously public extension services, which has been mentioned, funding for dedicated horticultural research and facilities was seen to have diminished in some way:

"In horticulture, I think it is people talking to one another, and I think horticultural funding and support from research institutes, has just been stripped away… I think that's something that the funding bodies don't understand, is we've lost a lot of support and facilities." (30)

What research is carried out, often involving the levy organisations, is subject to questions of fairness:

"… let's say ten growers of lettuce, one of them is hugely dominant, while the innovation's being done for them and the others look and say "well we can't implement that because we don't have that scale"." (19)

"I think things are changing there, 'cos I think there's these new BBSRC projects, these big BBSRC projects that are perhaps helping to some extent, but… some of these groups are quite exclusive. Inclusive rather. So if you're in the group you're fine, but if you're not in the group, you've hardly…" (6)

As described in Section 4.2.1.2, the consolidation of the industry has led to differing "agendas". Funding bodies and researchers themselves were seen to have their own agendas, which are not necessarily aligned with that of the industry at large (although, given the range of crop types represented by the levy organisations, finding aligning agendas is *inherently* troublesome).

The translation of research into practice remained a concern, though it was not clear what formal processes – if any – were in place across the research establishment to achieve this goal. What can be discerned is a variety of views as to "where" translation is required. Some considered translational research to be required between crop types:

"It used to be called strategic funding… taking knowledge from Arabadopsis, say, into crops and things like that- but you can't do it over and over again… [it's] difficult- 'cos there's a limited amount of funding and expertise, and do you want to translate… how do you fund it being translated into every crop?" (7)

"… the sort of wheel of virtuous circle is sort of working at the applied end of the research spectrum but it's just working in that applied end and that sort of communication back from the industry into the more basic end of the research spectrum isn't working so well." (9)

Others suggested that translation was required between applied research and the farm, particularly where research needed 'operationalising' (the traditional focal point of extension activities):

"And in terms if industry I think a big problem is you'll get posters up saying "this is the fantastic work we've done" and you'll get a farmer coming along

and you know they just look at it and think "oh crikey what on Earth?" it's not distilling it into practical information they need." (24)

A number of observations were made about researchers themselves, many of which reinforce the notion of 'distance' (or perhaps 'dissonance') between different actors in the industry. For example, researchers' understandings of on-farm, practical considerations were brought into question:

"They probably don't understand all the constraints and what they see is what a good idea it probably is, but what they don't understand is the knock-on effects or why it's not practical." (28)

"I think that they talk different languages." (8)

"And I think the difficulty is the way things are funded and in terms of being a scientist, to- you know have the success and move on, you're almost looking for different things tha[n] the actual practical application in the industry…" (24)

However, it is the researchers' own professional networks and ability to communicate their research that was seen to act as a barrier to sharing knowledge for innovation:

"In some instances researchers may be are not particularly well-linked into industry." (15)

"Unfortunately we generated a generation of very good scientists who are incapable- not incapable, inexperienced and unrewarded for interacting with industry." (19)

"Because it sounds good on paper, but again you've got the problem of a research scientist is not necessarily- or the people running the project aren't necessarily going to be the best ones to make that delivery." (6)

"… they don't command the growers' respect…" (21)

The various processes for establishing research orientation is likewise subject to scrutiny:

"I don't think for a lot of people there's a good enough process for evaluating the data. Working out what the problems are, and then feeding that into "what do we need next?"" (32)

"… if you chop the budget up into little heaps and it's annualized, then there they are in a defensive culture, what do you expect people to do? And also you've just basically exposed them to a series of little project proposals the research community has iterated to fit- 'cos it knows what size the budget is as well, so it knows what the culture is, so it knows what to get on the table that's got the maximum chance of getting the money." (31)

A distinct theme emerged regarding the loss of expertise and institutional, embedded knowledge in the industry over time, stemming from the loss of expertise, which also lead to the duplication of research by certain organisations.

"… most of the people who did anything are either retired or dead with the blueberries original in the nineteen- I mean it was planted way back in the seventies…" (23)

Closely linked to the loss of institutional/embedded knowledge across the sector, two factors seem to be prevent the retention of expertise:

1. *The nature of research funding*: the limited duration and project-driven nature of research funding can leave organisations without means to retain key staff. Likewise, the time spent drafting funding proposals is "wasted" if the application is unsuccessful (and occupies a lot of time for many researchers)
2. *Succession planning*: particularly within research institutions, it was felt that certain expertise was only one 'retirement' away from being lost, leaving current and future organisations without means to leverage that expertise and the duplication of research that might have been otherwise prevented had a key individual been involved in some way.

The duplication of research – seen as wasteful – was a particular complaint amongst researchers, who saw similar issues being explored years apart:

"And I'm now becoming a grumpy old man and yet I see things that are being done again that I thought "well, we did that twenty years ago". One of the

issues when we went to talk to [company] but they had an issue that had been researched on here by colleagues I knew here in the early nineteen eighties, but they hadn't found the papers, because the papers aren't necessarily in the databases when you search them. But it's there... but when I retire, and other people retire, that- you know, me knowing that they've wor- did the work in the nineteen eighties will go as well. Because I won't probably, there won't be a successor- I doubt there'll be a successor of me." (7)

For some, the loss of expertise and knowledge is not limited to the realm of the researcher: some pointed to a "prescriptive" mode of agriculture that has become common today and speculated that this amounted to a loss of tacit farming knowledge:

"… we've drifted, over the last eighty years, we've shifted from farming where there is an intuitive understanding about what you needed to do to do things right, to prescriptive farming where people have had the pesticides, and the agro-chemicals and they've lost that skill, that intuitive nature and they're still in prescriptive mode, but now we're losing all these ag-chems, but they're still in prescriptive mode, and they want someone to give them a ticket to sort the problem." (13)

Also evident was a sense that the formal research and development architecture, its outputs and institutions, were not at the forefront of technological progress:

"The problem with [public extension services] from an innovation perspective is they were often a long way behind the cutting edge." (21)

"I think in some instances the research establishment struggle a bit to get to grips with what is the next- current or next big issue." (32)

It is clear that there are blocking mechanisms within the formal research domain of the fresh produce industry, including the funding of research – its apparent decline and how funding should be spent – and questions of fairness with regards to the output of research. The loss of expertise at both research institutes (and, indeed, on the farm) is likewise a concern; the ability of researchers to effectively communicate with the grower-base and their exposure to the industry at large was questioned. A lack of formalised processes for translational activities also constitutes a barrier to innovation.

4.7.1.3 Economic factors

A number of economic factors, some of which have been discussed as inherent features of the modern fresh produce industry, also act to deter innovation. More than one participant simply said "cost" when asked what acts as a barrier to innovation.

The size of the horticultural market, both in terms of number of participants and its relative value, was felt to deter investment in product development:

"So if you need to spray something on potatoes then it's worth the chemical company producing the thing. If you need to spray it on hardy Geraniums, it's

never gonna- they're never ever ever gonna make any money out of that." (17)

"And that's where then horticulture it can be quite challenging, because you know, some crops- if we just take the UK market, there aren't that many producers of some crops, thing[s] have become highly specialized and you can count on two hands the number of growers…" (2)

"The other thing with our industry is that the UK is really quite small as a market. So for someone to design a baby leaf harvester in the UK, will be really wasting his time. 'cos he won't be able to sell any machines." (14)

The elevated importance of overseas sources of innovation may stem from these conditions. Another economic barrier to innovation is the high capital cost associated with many sectors of the fresh produce industry, which is itself due to considerable consolidation in those sectors (see Section 4.2.1.1).

Certain business relationships in the industry are also less conducive to fostering innovation than others. In general, this centered on the practices of retailers and processors with regards to their supply base:

Now when I have this conversation usually I start to get a bit pissed off, they'll [retailer] say "it's not like that [name], you've been supplying us for twenty years" [laughs] here we go. And you'd have thought that after twenty years you would learnt that actually you need to make sure that you assist your core supply base to improve its performance for you as a customer. What are you doing to help me improve my performance? What are you *doing to help me innovate? What are you doing to help me be profitable? What are you doing to helping me stick with you as a customer rather than go somewhere else which a lot of people have done? Or even just give up on... what are you doing to encourage me to continue to work night and day to supply you so you'll be successful and make money? What are you doing about that? Answer: nothing. (27)*

"Erm, I think in effect, I would have to be honest and say that the retailers can be a barrier. The retailer, all they want is consistency and cost reduction." (29)

As such, relationships built on a transactional, rather than collaborative approaches, are less mutually beneficial and can either impede or at least discourage innovative activity (see Discussion).

4.7.1.4 Regulatory constraints

Regulation is a further factor hindering innovation. The Basic Payment Scheme (a Common Agricultural Policy (CAP) subsidy for land-managers satisfying certain conditions) to land managers in European Union member states, for example, was directly implicated in de-incentivising innovative activity:

"I've been at a farmers' group meeting on this and almost to a man they were saying "we've got to stay in the European Union otherwise we wouldn't get our subsidies" and I'm saying "well that's the problem". That's part of the problem." (27)

“I think the greatest thing that holds back innovation in this country… is the subsidies that you enjoy.” (29)

“You know you get rid of subsidy and you get rid of the laggards…” (8)

“It stifles innovation…” (16)

The removal of certain pest control products was, as previously noted, a particularly contentious issue, though this is only a barrier to innovation where, as one participant pointed out, companies that would otherwise register new pest control products in Europe were being prevented from doing so:

“Yeah and the disadvantage the EU is putting EU member states... against other parts of the world. It is very apparent that all the major crop protection companies are increasingly less willing to spend the money on registrations in the EU, because they can effectively get more bang for their buck in other parts of the world and maybe if they can earn enough money out of a product somewhere else they will bring it in to the EU.” (15)

Most problematic is the mismatch between the rate of removal of such products and the level of support offered for finding replacement products or substitutes by the very institutions that instigate such measures:

“… the government has an underlying strategy of sustainable growth in horticulture. That seems to be at odds with the European Commission's- the

fervor in which they're putting into removing a lot of the active ingredients. If they're bad, and if they're proven to be bad by all means get rid of them but I would also like to see the same amount of fervor being placed into supporting research and activity around integrated pest management." (29)

In summary, it is 'political' choices at the multilateral, European level that are perceived to constitute the gravest barriers to innovation in the UK fresh produce industry.

4.7.1.5 Culture

The notion of a national *culture* was also invoked as a barrier to innovation:

"… we've created this terrible culture, which is a contracting, defensive, you know, narrow, containing culture." (31)

A combination of both political choices and the inherent competition found in the UK fresh produce industry has led to a "defensive innovation" culture in which innovation is 'limited' to reducing costs and improving efficiency, at the presumed expense of more far-reaching change. Of course, this is reflected in other issues, such as the lack of willingness to collaborate on issues that might otherwise be mutually beneficial and negative supplier relationships:

"And we had a big retailer in the UK, very positive buying team, very effective buying team, a hundred and thirty garden centers, good people to supply, interesting innovation, interesting new products, great people to work with.

New buyer comes in and says "right we've got to turn this into a company, really, really makes money. So we need to see- we need to push up the margin… we want to see prices come down, and that's the focus". So you come and tell me, as we did go and say to them "look we've got a red leafed-hardy Geranium, I know it's a little bit more than your other Geraniums, but ours is a red leafed hardy Geranium. That's why you're paying us 50p more than you're paying anybody else for the Geraniums, 'cos we pay a royalty on it, it's awkward to grow, it's difficult to propagate, nobody else has got it, we are the only growers in the UK, it really works for you" and they'll say "I'm not interested in your red-leafed Geranium, I just want Geraniums and I want the price down". And they pushed it and pushed it and pushed it, and so it was a really- fortunately we only had five, six percent of our turnover with these people and they dropped us because it wasn't where we're at…" (17)

These observations were generally contrasted with the past, in which a more collaborative spirit was, rightly or wrongly, pervasive. This is discussed in more detail in Section 4.9.

4.7.1 Personal barriers

Personal barriers are those that primarily concern individual actors with regards to innovation processes. For example, the inherent uncertainty of innovation, and the fear and risk that engenders, was seen to constitute a major barrier to innovation:

"The biggest thing that holds back innovation is fear. Fear of failure." (1)

"I think there's a fear of... going into the unknown." (21)

"Erm the reward to the innovator is very uncertain." (19)

"I mean it's a brave farmer who actually goes out on a limb and actually starts doing something completely different to all his peers. You know they all laugh at him and take the piss out of him at the local pub and all of that sort of sting." (8)

"If your livelihood comes from growing a certain crop in a certain way using varieties that you understand in production systems you understand, any change in that is a business risk." (10)

Indeed, uncertainty also plays a role in setting the research agenda:

"I think a lot of them don't know what they need." (13)

"… the growers aren't- they're not necessarily- they might have a little problem, but they're not aware that there's fifty people with the same little problem…" (17)

"I remember going to one meeting where somebody has said that the top fruit industry has no research requirements... what?!" (8)

The traditions, skills and even age of those in the farming community were likewise given to be personal barriers to innovation:

"… "this is what we've done before, we haven't had any problems with it, why should we change our behavior?"" (6)

"… "we've not done it this way before we're uncomfortable with something new."" (8)

However, it is interesting to note that the 'personal barriers' to innovation remained rather less expansive and thematically consolidated than those systemic barriers identified in the previous section (addressed in Discussion).

4.8 Enabling factors

Having looked at the systemic factors blocking innovation, the question underlying this section is: what can be done to facilitate it? Again, the findings can be divided into *systemic* and *personal* enabling factors, but there are several distinct themes in this category that sit between and across both systemic and personal factors fostering innovation.

4.8.1 Systemic enabling factors

There are various forms of support for innovation in the fresh produce industry, which, importantly, rely on interaction between different system actors:

"… we invest a lot of time that actually- working with the very early stages of product development, which in produce is the breeders, the plant breeders, the nurseries, the seed houses, and that they are often asking: what do you

think the market will want in five to ten years time? What do you think about this? What do you think about that? Rather than necessarily sitting in an ivory tower in a retailer, and going- expecting everything to come to you, and then have a meeting sort of thing and people have invested five years of their work and you go "oh I don't know why you did that, that was a bit of a waste of time" and can be very demoralizing…" (33)

"We collaborated with [research institute]. We had ideas and we got them to take it forward for us. A lot of money invested in that." (26)

"… you had companies that were in different parts of that supply chain working together so that when it came to taking that innovation to market everybody was already working on it together and some of the cost of course was taken care of by Defra…" (2)

Support can also come in the form of financial and/or strategic support mechanisms:

"… so our operational program which is funded by the EU… gives us the opportunity to invest in these areas." (26)

Of course, this necessitates action in terms of building networks and seeking such opportunities:

"… we've got to have some focus on some of these more challenging areas and that might mean we have to put some much larger pots of money on the

table, and if we can't afford all of that money then we're going to have to go to Innovate UK or BBSRC or [Horizon 2020].” (31)

“… equally people might be pushing ideas to us [retailer] and saying "what do you think about this?”” (33)

“I think that comes from, er... interplay between the producer and the retailer. It comes from the retailer saying "what can we do that's new?" and the producer saying "well I've got this idea, would you sell it?". And the way the supply chain is at currently is that the retailers go back to the big suppliers- the category managers and say "OK, what innovation have you got for us?”” (19)

Some dubbed this “challenging others to innovate”, a more direct request for collaboration with innovation in mind, representing a major catalyst for innovation in the fresh produce industry:

“Generally speaking how it would go... some of the needs would come through our agronomist, so we'll challenge our agronomist with a need.” (21)

“… I look after this pea operation, I act as a company secretary for it, and I've just taken a [unclear] and I said to them you are directors of the company… you know what are we doing to improve the performance overall, or are you happy with the performance? And they said "well no one's happy with the performance". "Well what are we doing to improve that?" and- well there was kind of a certain resistance, I think because they were being challenged as people with roles in the company, they were being challenged about how

they deliver those roles and I said "well is the performance good enough across the group?" "Well, it is what it is". "Yeah but could it be improved?" "Well, I don't know". "Well have you ever asked yourself?" "Well no we haven't". And after a while we began to get some kind of agreement that actually something might be possible here, and so we took it then to a board meeting, and I presented this idea that we needed to challenge everything that we were doing a little harder than we currently did. And the board actually took this on board, straight away and went "actually this is quite exciting, we've never done this as a board."" (32)

In parallel to the regulatory barriers described in Section 7.7.1.4, the promotion of certain policies, or, in some cases, the removal of certain policies, can facilitate innovation. Intellectual property protection (IP), for example, is a mechanism by which certain actors, notably breeders, protect the product differentiation that remains so important to the fresh produce industry:

"But you know I wouldn't be doing what I'm doing now if we didn't have IP protection... because why develop something- it's a business, and it's quite a successful business, but if I can't earn money from selling plants, the royalty from selling plants, because it's not protected, it's just an intellectual exercise." (11)

"… more in keeping with a typical industrial business, [horticultural businesses] see innovation and intellectual property as an opportunity to differentiate themselves in the market place." (8)

As noted previously Basic Farm Payments (BFP) and other forms of subsidy are considered by some to deter innovative activity. As such, their removal – to create what one participant called a "level playing field" – could also bolster innovative capacity (see Discussion).

Quite apart from Section 4.7 (*Industry "Blocking Mechanisms"*), in which the majority of barriers to innovation were found at the 'systemic' level, enabling factors are overwhelmingly found at the 'personal' level.

4.8.2 Personal enabling factors

Personal factors for change exist at the level of the individual person or organisation/business, and can be divided into several further categories.

4.8.2.1 Interactivity

As should now be clear, innovating actors most commonly rely on a personal and professional network of peers and others in the innovation system. Actively engaging with these people and organisations is a primary mechanism by which innovation is fostered:

"… you've got to get involved in the [AHDB] to get the most out of it." (1)

"So the more work the more projects which you do and more relationships you have actually spending time with the scientists who plug into different levels of thinking, so we're talking to somebody about a project but then we'll talk more widely about other things, and have a bit of a brainstorm, and they're throwing questions at you and then "oh well we hadn't really thought

about that but that's quite an interesting idea" and they'll ask us "what do you think about this?" and "oh that's quite interesting we hadn't really thought about it but do you know what that's quite possible" or "do you know what that's a complete and utter waste of time, I don't know why you're coming from that" so it becomes a very mutually beneficial exercise." (21)

"Well I think a lot of the time it does come down to individuals- how well do you know individuals in various sectors and the networks that exist and the connection between researchers, AHDB, growers, agronomists, and if that's all linked up, it can work very well." (15)

"Right from the bottom up, the entire supply chain needs to start to adopt modern methods. They need to look at a co-dependency, through the chain, working together in a collaborative way- which they're not." (27)

However, the choice of how or whether to interact with other industry actors relies on human resources such as time and competency, discussed below.

4.8.2.2 Human and material resources

Human and material resources are the resources with which a firm undertakes its activities, including knowledge (human capital), assets (financial capital in the form of equity) and access to capital (debt capital). Such resources play an obvious, but important role in innovation processes:

"So I think innovation's not just about the nuts and bolts of the system, or the equipment or whatever, it's again the human element." (15)

For example, "attitude" and (working) "culture" both play an important role innovation. These can be embodied in an individual, or a business as a whole:

"I mean, thinking about business, the working culture, so you have an environment where there is time to be creative... time and permission to try different things... and where mistakes are forgiven. 'Cos if you live in a fear culture, you'll never try anything new. So culture is absolutely critical." (1)

Competency is also a factor, with some participants suggesting innovation – with its inherent risks and uncertainty – is "not for everyone". Expertise, developed through experience and exposure to industry practices (learning by doing) is perhaps an obvious source of such competency. Indeed, core competencies make innovation across different categories of innovation that much easier:

"… these blueberries will go into hydroponics, so they'll be going into cocoa-fiber, we've already been growing blueberries in the soil outdoors for years, and understanding how they can grow but that's almost grown like our blackcurrants and our red currants, however now this will be copying differently because a blueberry has different requirements, how we grow our raspberries in pots. 'cos we've for probably ten years been growing raspberries in hydroponic pots- grow pots, and strawberries for at least ten years. So we've got a knowledge of hydroponic watering requirements and

the technology. So yeah the blueberry a lot of the knowledge is transferred across even the support systems we'll use to hold the crop up and support the crop those are borrowed from our raspberry technology." (35)

Interestingly, despite (or perhaps because of) the importance of competence in innovation processes, a reliance on "instinct" and "gut feeling" was still evident in some cases:

"Difficult to be certain on that, but that's a gut feeling is that some days you'd be better off [putting cherries] outside [to avoid cracking]." [34]

Beyond having greater financial resources with which to invest more in expensive technology and infrastructure, larger companies also have the human and material resources permitting them to deploy specialist staff (such as technologists) in the pursuit of new ideas and to take part in formal research forums such as levy board steering committees:

"So effectively the interface is with one business and they've got a lot of money, they can afford to employ important, very good technical people so they might have one really good technical director and their job is to think about lots of things… but one of their priorities is innovation. So they can go around and they can keep things going but their one vision, they're the one interpreter, they're the gateway- not the sole gateway but they'll have a big influence on what's going on in the innovation agenda." (19)

"… so if you take [companies], they employ people who are highly qualified technical people, either people who've worked for us, or research

organisations or whatever, but they're only gonna need one or two of them, a small team perhaps three at most… and they go round and they're really good at foraging, so they look at all the technologies worldwide, you know- and they go to lots of conferences, yeah, foraging, and they come back and they bring back and plant it in the business as much as can be uptake and that's always a good thing…" (31)

Human and material resources are clear elements in innovation processes; knowledge, financial assets and access to capital, competence, attitude and culture all provide the means with which to innovate.

4.8.2.3 Champions as change agents

Champions, gatekeepers and agronomists, those that pioneer new ideas and influence the direction of innovation through interaction with others in the industry, represent important actors in innovation processes.

"There are some inspirational people around." (1)

"It comes down to the people oh yes. I think people are very very important in this. You have to have your captains. Your champions." (6)

"I suppose it's one of the things that's worth mentioning, is the importance of having industry champions. Who can communicate and are well-regarded…" (18)

“So there's got to be a patron... along the chain, who's gonna champion it, and so innovation needs- if you went into a big corporate business, innovation would have patrons or champions that would actually take that through.” (19)

Agronomists fulfill similar functions (i.e. can be champions or gatekeepers in their own right), spreading solutions to agronomic issues:

“… well [agronomist] spends all of his time busy at nurseries and busy seeing different- and sometimes it's just the fact that he's seen somebody else with a similar problem and they've cracked a solution…” (17)

Of course, the ability of an agronomist or any other champion to influence on-farm decisions is derived from in part from trust between their customers and themselves.

4.8.3 Trust

Some enabling factors sit between the systemic and personal realms, but intersect both. For example, “trust” is an essential component of relationships where innovation is the objective, between people *and* between their respective institutions:

“I think it fosters a partnership and trust which then allows both parties to partake in innovation because this is a big problem, if you need partners to work together they need to trust each other…” (20)

"... being able to collaborate and share knowledge when it's trusted partners, it's quite important. I think trust is such a big thing in life in general, but I think when you're talking about innovation development, people being able to trust that if they share something with you that you're not just going to broadcast it on Twitter to everyone that- you know, there are certain things that people are very happy to share, there are other things that are very bespoke projects that they kind of want to get an idea of "whether do you think this is a good idea?" but you have to keep under your hat for a while... a lot of it's down to peoples' values in these sorts of things, and business ethics, and how business goes about things..." (1)

The term "respect" was also used to describe mutually beneficial relationships, indicating the importance of social factors in the innovation process.

4.8.4 The idea of best practice: in farming and in extension

A further factor that arose during the course of data generation is "best practice", which here takes two forms: the notion of best practice in farming – that there are better, evidence-based methods of production – and its equivalent in extension practices – that knowledge-producing organisations can adopt better or worse means of communicating their outputs with the growing community. How one relates to the other, and, indeed, whether either constitutes a reality in farming at all, is somewhat difficult to unpack. For example, despite the apparent need for the establishment of a "best practice" model for farming:

"… we need to turn all of that output into coherent best practice kind of format. So whatever new knowledge emerges become integrated into the current best practice model, which is continually iterated and improved…" (31)

… it was widely recognised that innovation is a negotiated process often involving not just the adaptation of a given product or process to the special circumstances of a particular operation (see Section 4.3.2, "Observations about innovation"), but appreciation for the right time with the respect to market development:

"… there's always a right time for everything…" (1)

As such, it is clear there is no "one size fits all" approach to innovation in farming. What we see instead is the "fit" of a given innovation to a particular circumstance. It is the appropriateness of new ideas or products in a certain context that determines the ease of their implementation:

"Well I think one of the things you learn in applied research is that you can do a wonderful piece of research which shows you can do X, Y, Z and it'll have some sort of benefit but unless it fits in to whatever system growers are using, and unless it actually does something to their bottom line there's not much incentive for them to actually do it." (9)

Furthermore, the nature of the innovation itself will determine what "pathways to use" are used by organisations charged with extension activities:

"… it depends if your innovation's an active ingredient, a germ-line, if it's a piece of machinery, control system, decision support, they're all gonna have very different sorts of creators if you want and also have different pathways to end use." (19)

The notion of "fit" is a something of a challenge to the idea of best practice, representing the diversity of contexts within which innovation occurs in the fresh produce industry. Likewise, it has implications for the design of research and determining the 'impact' of research later on (see Discussion).

The precise methods by which agricultural knowledge could or should be shared remained quite general, resting in some cases on the type of information one is dealing with:

"We do have the view here that the delivery of information is a multichannel activity and it's er, it's a question selecting the right channel or channels for whatever message it is you're trying to get out there." (9)

There was some disagreement, however, over the supposed value of certain activities, again reflecting the principle that extension, like innovation, is most often context-specific. For example, some claimed "seeing was believing", referring to the need to demonstrate in practice an idea or product to prospective users:

"I have this with my own growers, if I can show 'em a trial, that I've done, that's worked, and I can demonstrate to them... what I've changed has made a positive benefit, then they'll adapt it." (1)

"Demonstration, I think. Best way is to get farmers on a farm. So face to face." (8)

However, others challenged the assumption that demonstration is always effective:

"Erm... well people always talk about "oh demonstration farms" and things like that. They've been tried on and off over the years. The reality is what works on one farm, does not always work on another farm." (15)

The recognition that digital/mobile communications were becoming increasingly prevalent, however, was less controversial:

"Increasingly I'll get something sent to my smartphone in terms of a picture from a grower saying "what's this?" you know." (15)

Given the age profile of the UK's farming community, though, meant that print communication was still considered effective. At the same time, the involvement of stakeholders in the research process was seen to provide more than the 'obvious' benefits of receiving the output from said research; boosting research relevance in its initial stages, for instance, and knowledge that might otherwise not be published:

“I'm probably fortunate that I've been part of R&D committees, I get to see a lot of proposals coming through and seeing what people are looking at on the research side, and trying to make them practical on how they can be applied on the field side…” (28)

“… for every bit of public information, there's probably a couple of bits behind the scenes that weren't published which has value and that's one of the reasons why we like to do a lot of our own R&D work for [AHDB] or whoever, 'cos then we learn more than necessarily is published about different aspects...” (13)

In summary, whilst enabling factors for change hinge on effective communication – facilitated by trust and by peer groups, for example – the precise means by which knowledge can best be communicated remain difficult to appreciate fully, in part due to the diverse contexts in which innovation must occur. Factors such as capital and human resources also play an important role, the lack of which can disproportionately affect smaller growers.

4.9 Comparisons with the past

In discussing the current ‘state’ of innovation in the UK fresh produce industry, comparisons with past circumstances were common. With regards to innovation, the privatisation of the formerly-public extension service was clearly a pivotal moment for those involved in the industry:

“God it's a long time ago. It took a long while to miss ADAS... but I think we do miss 'em now. As an industry.” (1)

“… maybe I'm just thinking [of] it as a golden age, you know looking back and thinking how it was good in the old days. It's just different, it's just different…” (7)

The changes to agricultural knowledge provision in England and Wales after the late 1980s is the precursor to many of the problems found in a number of areas across the industry today. In general, this hinges upon the loss or disruption of established networks, access to and loss of expertise, loss of the ‘boots on the ground’ advisory workers, and a lack of willingness to share knowledge:

“… and there was then ADAS you could just approach- I could ring up the tomato specialist at ADAS and say “we're interested in doing this, can I come and talk to you?”, just generally talk about how we might go about it who might be able to help.” (2)

“I think researchers are more isolated from the industry than they used to be in the good old days when you did have ADAS and a state extension service whose job was to interpret research findings and then put them into practice and take them out to the field.” (7)

“… the old boys and girls who were leaving [the industry], they talked about the days when someone came and said "here's your contract, go away and work out what makes an onion tick" and I think that's it, you had free-reign,

you could do what you wanted, and you had lots of people who then were growing onions who'd all be coming saying "how does that work then?" and then they'd go away and they'd try to implement these systems and there'd be lots of them, but now there's not lots of them." (19)

"... now in this sort of fiercely competitive sort of environment where we're not prepared to share as much as we did in the old ADAS days, when it was more or less a fair- people used to rock up at events and they would share their innovations, so businesses that were leading the way would be quite relaxed and comfortable about allowing others to look over the fence and there was a lot of that behavior going on, that pulling through the followers..." (31)

However, it seemed that whilst the impacts of these changes have been far-reaching and continue to pose problems for the industry in certain areas, it was acknowledged that era of public extension had problems of its own:

"... you know having been inside it, and come in at a stage where- with a sort of fresh pair of eyes if you like when it was about to start changing very radically, that it had gotten into a rather sort of cosy position and I think the idea that ADAS was the primary channel of change in industry was... I'm not certain that it did as much as it might be credited for." (9)

"The problem with ADAS from an innovation perspective is they were often a long way behind the cutting edge..." (21)

It is clear that comparisons with the past offer participants a frame of reference with which to compare current circumstances. The implications of political choices – primarily concerning the provision of innovation support services – continue to reverberate into the present; we also see a form of 'nostalgia', represented by the notion of there having been a "golden age" in the past.

4.10 Challenges

Whilst comparisons with the past are interesting in themselves and provide context for present circumstances, of more immediate concern are the challenges faced by the industry as a collectivity today. These centre on the issue of *sustainability*:

"I suppose you'd sum it up as improving the sustainability of UK businesses. And by sustainability, that's economic sustainability and environmental sustainability." (32)

However, factors such as price (return to the grower), availability and cost of labour and foreign competition are *economic* challenges to the sustainability of the industry:

"Yeah, remaining competitive is the biggest- that's the biggest challenge, that expresses itself many ways." (1)

"At the moment- today's greatest challenge is return to the producer." (19)

"Price. Supermarkets... it's- I should say the costs of production, but I've nothing against the costs of production, we are facing one of the biggest challenges we've ever faced and it's price wars." (26)

"I think one of the big issues for fresh produce which is slightly different from normal farming, is labour as well. Not just cost of labour but availability of labour as well. I mean you go to... I mean- and that's now getting tied up with issues about immigration and things like that so becoming highly political issue with the fact that we have a- you know most of our big horticulture companies are employing eastern Europeans, because- oh I went to [company] a few weeks ago, they have one UK national working on the harvesting side of the operation." (7)

"… there's competition from overseas because there are lots of other countries with better environments for growing things, which are scaling up their own production…" (6)

The loss of active ingredients – without the registration of suitable substitutes – also poses a challenge to the economic sustainability of the industry:

"I think the main challenges are crop protection... the government has an underlying strategy of sustainable growth in horticulture. That seems to be at odds with the European Commission's- the fervor in which they're putting into removing a lot of the active ingredients. If they're bad, and if they're proven to be bad by all means get rid of them but I would also like to see the

same amount of fervor being placed into supporting research and activity around integrated pest management." (29)

Equally, environmental sustainability, particularly with regards to climate change, is a challenge:

"Erm, climate. I think climate's significant because there's no doubt that it is going to be an increasing challenge." (16)

"And a final one of mine… would be climate. And that's a long-term one." (19)

Many of those factors influencing innovation in the fresh produce industry outlined in this chapter were considered challenges in their own right. The loss of expertise for example, continues to be seen as a threat to the industry:

"I think loss of diversity is a problem. It's a problem in terms of growing, we grow fewer and fewer varieties and crops, the genetic pool and it's a problem in terms of expertise we've lost diversity in expertise. And so when we have an unusual problem, we don't have the unusual person around anymore [laughs]." (7)

Changing behaviour is also a challenge, at least with respect to consumers:

"I think there's a communication challenge as well, around the benefits- particularly the health benefits of fruit and vegetables that has singularly failed to resonate with consumers. I mean everyone knows they're good for you, but- you know the communication that's out there hasn't changed

behavior, so people might say well we've done a lot of communication and we've raised the awareness, but raising awareness if it doesn't change behavior is of limited value. So I think that's a challenge." (10)

In summary, the challenges for the industry centre on its longer-term sustainability, both at the economic and environmental level. Changing consumer behaviour – by espousing the benefits of produce – could also be a means of bolstering the industry's economic viability.

4.11 Summary of Findings Chapter

This chapter has explored how the data was generated, including who was approached for interview and the roles and geographic locations of interviewees, in addition to outlining the steps taken to build up an analytical framework in keeping with Framework Analysis; this produced 9 interlinked themes that have been outlined below.

Norms and institutions (Section 4.2)

This section explored the nature of the modern fresh produce industry, including its increasing competitiveness and consolidation, as well as the role of key institutions as innovation support services – such as the levy organisations – and the influence of retailers.

Innovation in fresh produce (Section 4.3)

This section examined how those who engage with innovation define and measure it. It also explored more general observations about innovation processes, including the notion of unpredictability.

Drivers of change (Section 4.4)

This section dealt with the drivers of innovation in the industry, which are overwhelmingly economic and are primarily driven by the needs of the retail sector through which most produce is sold.

Sources of innovation (Section 4.5)

This section explored 'where' innovation comes from: this turns out to be an intensely social process, but also an international one, given the strong emphasis on overseas sources of innovation. Individuals, private firms and research institutions also contribute to innovation through formal and informal means. Likewise, learning by doing and experimentation is a prime means by which new ideas emerge.

Communication in the fresh produce industry (Section 4.6)

This section concerns how actors go about communicating with one another and focuses specifically on positive interfaces – including personal and professional networks, agronomists and producer organisations – and barriers to effective communication, such as the high level of competitiveness found in the industry preventing the sharing of otherwise useful knowledge.

Blocking mechanisms (Section 4.7)

This section explores the barriers to innovation in the fresh produce industry by separating them into two groups: systemic barriers and personal barriers. Systemic barriers to innovation include fragmentation – or lack of vertical and horizontal coordination – and decreased funding for horticultural research, differing research agendas and difficulties in both demand articulation, from the industry, and understanding of industry constraints by researchers. Other systemic barriers include economic factors such as the size of the UK produce market that serves to deter significant investment and negative commercial relationships between suppliers and retailers, as well as an unfavorable regulatory environment and "defensive" innovation culture. In contrast, personal barriers to innovation hinge on risk, uncertainty and the fear of failure.

Enabling factors (Section 4.8)

This section examined what can be done to facilitate innovation at the systemic and personal levels, but also in ways that transcend this dichotomy. Systemic support for innovation relies on fostering that interactivity and those networks shown to be vital to innovation in preceding sections; however, unlike the barriers to innovation, of which most were systemic in nature, personal enabling factors rest primarily at the level of the individual or organisation. "Getting involved" in projects or with specific institutions for example, provides a direct interface with peers. However, it is human and material resources that best determine the ability of an individual or firm to innovate. Trust is an important factor for innovation, as are champions, influential pioneers of innovation. Lastly, an appreciation for the "fit" of a given innovation, by understanding its context, is paramount.

Likewise, extension practices are context-dependent, requiring different approaches not only for different people but also for different "types" of innovation.

Comparisons with the past (Section 4.9)

This section outlines the ways in which present circumstances are contrasted with, and linked to decisions made in, the past. The privatisation of formerly public extension services was understood to be a decision that is still being felt, ultimately responsible for the fragmentation of the industry today.

Challenges (Section 4.10)

This section outlines the challenges faced by the industry today, centering on the idea of sustainability, both economic and environmental. Ensuring that new pest control products or practices remains a priority, as well as improving the return to producers to bolster re-investment. Changing consumer behaviour will also be a challenge in the foreseeable future.

Chapter 5: Discussion

This chapter will discuss the overarching themes that have emerged from Chapter 4 (Findings) and to compare and contrast these with existing literature, to provide answers to the research questions that frame this research project. It will also outline the way in which the need for rigour has been met, and will reflect on the benefits and limitations of the chosen methodology used in this study.

5.1 Introduction

The AIS framework postulates that an agricultural innovation system is "… a network of organisations, enterprises and individuals focused on bringing new products, new processes and new forms of organisation into economic use, together with the institutions and policies that affect the way different agents interact, share, exchange and use knowledge" (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a, p. 2).

Although broad, this definition appears to fully capture the nature of the phenomena observed in the previous chapter: the importance of personal and professional networks, the mix of organisations, firms and individuals in innovation processes, the active search for different types of innovation, and the institutional and regulatory norms that shape the outcomes of innovation. The study has discerned a number of ways that this arrangement has determined – for better and worse – the way actors interact, share, exchange and use knowledge. The unpredictability of innovation (see Turner, Klerkx, White, Payne, & Everett-Hincks, 2015b) is also corroborated by this project (Section 4.7.1), as is the importance of interactivity (Section 4.8).

One way of interrogating the findings of the study, and providing a means to further develop recommendations for improving innovative capacity in the industry, is through a systematic functional-structural analysis in keeping with functionalist AIS diagnostic work undertaken elsewhere in AIS research (see Section 2.4.2). This offers a means to explore the findings of this thesis and provides a point of reference for where novel or conflicting views have emerged in this study.

5.2 Functional-structural analysis of the fresh produce industry

As described in Section 2.4.2 of Chapter 2 (Literature Review), the seven functions of innovation systems are as follows:

1. Entrepreneurial activities
2. Knowledge development
3. Knowledge diffusion
4. Guidance of the search
5. Market formation
6. Resource mobilisation
7. Creation of legitimacy

There are also three 'structures' that determine the operation of these seven functions:

1. Actors
2. Institutions
3. Infrastructure

Each of the 'barriers identified in the preceding chapter correspond to one of these seven functions, which form the basis for this analysis; likewise, each failure concerns *actors*, *institutions* or *infrastructure*. Table 11 (below) outlines the contextualised systemic problems affecting the UK fresh produce industry (Kebebe et al., 2015; inspired by similar analyses by Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a) and offers potential *systemic instruments* to combat problem areas (see Hekkert et al., 2007).

5.2.1 Entrepreneurial activities

As Hekkert *et al.* (2007, p. 422) point out: "There is no such thing as an innovation system without entrepreneurs". A strong vein of entrepreneurial activity runs through the fresh produce industry; this is shown through examples of – sometimes revolutionary – change, as displayed in the case of polytunnel use across the UK, but also by more modest experimentation and incremental improvements. Hekkert *et al.* (2007, p. 422) note that, "by experimenting, more knowledge can be collected about the functioning of the technology under different circumstances." As such, entrepreneurial activity at this level contributes to broader knowledge development (see next section) and reinforces the notion that entrepreneurial activity is a key source of innovation, in accordance with other studies (Knudson, Wysocki, Champagne, & Peterson, 2004).

A perception that the fresh produce industry is a more industrial, entrepreneurial sector of UK agriculture relative to other sectors is also evident Section 4.2. In stark contrast to what Turner *et al.* (2015a, p. 4) describe in New Zealand, where a large number of SMEs lacked the resources to undertake entrepreneurial activity, the UK fresh produce industry is increasingly consolidated, through both traditional business acquisition and vertical integration, or through producer organisation-type partnerships, resulting in the economies of scale required to invest in significant projects. The presence of a strong entrepreneurial base is considered the sign of a well-functioning innovation system (Hekkert et al., 2007, p. 422). As Hekkert *et al.* (2007) assert, the number of new entrants and the diversification activities of incumbent actors also serve as indicators of entrepreneurial health; given the consolidation of the industry and associated high capital costs, the number of new entrants in the industry is likely low though this research has captured examples of diversification activities by incumbent actors (see 4.3.3.3).

Going further, it is also clear that entrepreneurial businesses and individuals rely on personal and professional networks to achieve their 'innovation agendas'. Likewise, growers and other businesses often maintain close links with individual researchers and the institutions to which they belong. Whilst these farmer-scientist relationships are not free of the tension described by Ingram (2014), they constitute a vital conduit for knowledge and were expressed in positive terms (see Section 4.6.1.1).

5.2.1.1 Barriers to entrepreneurial activity and mechanisms for change

A range of barriers explored in Chapter 4 prevents or slows entrepreneurial activity, some of which overlap with other systems functions. The small relative market size of UK horticulture, acts as both a driver of innovation – forcing firms to invest in their own specialised equipment – and deterrent to further investment, leading firms to look overseas for their needs. A diminishing return to growers was cited as a barrier to investment in innovation, and a cause of increasing consolidation across the industry. Intense competition between firms limits the amount of knowledge shared (horizontal fragmentation). In a post-public extension service environment, firms have a strong interest in protecting the commercial value of knowledge (Lamprinopoulou et al., 2012, p. 16) and knowledge-sharing between agricultural advisors has been found to have declined (Klerkx et al., 2006). As Klerkx observes (2009, p. 853):

"Whereas the public knowledge infrastructure used to be characterized by a high degree of interaction, the privatized knowledge infrastructure has become disintegrated. Market and system failures have emerged, such as information asymmetries, which hinder the setup of innovation networks."

Some of the negative, exploitative relationships found between suppliers and their customers in the industry also represents a barrier to innovation, providing less impetus to innovate and preventing the exchange of otherwise useful knowledge between different organisations (Section 4.7.1.3). That 'lead firms' seek to control the food-supply is understood (Mylan et al., 2014, p. 21). Likewise, the possibility remains, and is perhaps evident in this case, that "… large contractors will use their market power to depress the prices paid for inputs, and to make other contract conditions disadvantageous for producers" (Young & Hobbs, 2016, p. 432). Rovoredo-Giha *et al*. (2012) also found that, in the UK potato sector, the success of innovation is highly dependent on the supply chain "leader", most commonly a retailer. In turn, this has motivated producers to form producer organisations for the sake of consolidated bargaining (common throughout Europe) (Young & Hobbs, 2016, p. 432). As Rovoredo-Giha *et al.* (2012) put it:

"Because the position they are in the supply chain, operating individually [farmers] have little chance to start potentially successful innovations of their own and their best chance is to operate within a supply chain where the chain leader organises growers and proposes innovations that take into consideration what customers and consumers want."

In effect, this corroborates the claims of those participants in this study that find supportive commercial relationships more conducive to innovation (see Section 4.8.1).

It would appear that a dual *asymmetry* is present in the industry. The first, *information/knowledge asymmetry*, signifies an imbalance in the relative knowledge of different actors, leading to a gap in which they are imperfectly informed about possible cooperation partners and what those potential partners can offer (Klerkx & Leeuwis, 2009). It has been noted that this complicates the search for such collaborations and raises the transaction costs for businesses (Lamprinopoulou et al., 2012, p. 17). Duplication of research or experimentation (as observed in Section 4.7.1.2) is a further consequence of information asymmetry.

The second, *asymmetry of power*, indicates an imbalance between actors in terms of influence and market strength. Here, the primary focus is on the power of retailers over other supply chain actors, which has been noted as a feature of the UK agri-food system (Lamprinopoulou et al., 2012). Such asymmetries represent *market failures*, and are often linked to fragmentation in the wake of privatisaion of extension services (Klerkx & Leeuwis, 2009; Klerkx & Proctor, 2013; Lamprinopoulou et al., 2012; Leeuwis, 2000). As in Lamprinopoulou *et al.*'s (2012) study of the Scottish agri-food innovation system, retailer bargaining power represents a barrier to innovation, although it has been acknowledged that retail markets and supermarkets can offer opportunities for innovation and constitute a significant driver of change in themselves (a dichotomy referenced in Sections 4.7.1.3 and 4.8.1).

We might choose to cast the structure of the UK fresh produce industry as an *oligopsony* (see Rovoredo-Giha et al., 2012), exhibiting *interaction* or *network failure* according to Weber & Rohracher's (2012) typology; *weak* network failure occurs in instances where a lack of interaction between actors limits opportunities to realise complementarities, interactive learning and new ideas (see also Klein Woolthuis et al., 2005). However, the severity of the negative relationships described in Section 4.7.1.3 suggests that these problems transcend network failure as outlined by Weber & Rohracher. In fact, none of the 'systemic' failures described in the relevant literature adequately capture the situation in the UK produce sector, which demanded the creation of a special governmental adjudicator[15] and is described as “one of the most cutthroat and competitive in retail” (Retail Think Tank, 2015). Since “innovation is positively influenced by integrated cohesive networks with trust-full relationships” (Mylan et al., 2014, p. 22), the lack of trust between suppliers and their customers may indeed pose a significant barrier to innovation. The relative gains of innovating are nullified by the need for continuous change despite few rewards for the effort, destroying a key driver of innovation (see Section 4.2.1.1 and the concept of the “innovation treadmill”).

It was observed in Section 4.8.2.2 that human and financial resources were a strong determinant of innovation. As such, where firms are incapable of leveraging the appropriate competencies and resources, *capabilities failure* is evident (Klerkx & Leeuwis (2009, p. 850) also call these ‘managerial’ gaps). This is not the case for all actors or firms, but appears to be subject to differences in size. Likewise, this is not to say that all actors must choose the same “technological trajectory” as Weber & Rohracher (2012) describe it – indeed, as shown in Section 4.8.4, innovation is often context-specific – but limited resources may constrain the ability of a business to adapt to changing circumstances. Woolthius *et al.* (2005, p. 610) warn that this can leave smaller firms “locked in” to existing technologies, unable to transition away from a given regime.

[15] An independent, fresh produce (“groceries”) adjudicator was commissioned in 2013 to oversee the commercial relationship between suppliers and supermarkets (see https://www.gov.uk/government/organisations/groceries-code-adjudicator)

Ultimately, a decisive barrier to innovation is the inherent uncertainty of change (see Section 4.7.1). That innovation is an uncertain process is not controversial (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a) but there are limited means to reduce this inherent uncertainty (see below).

When it comes to overcoming these barriers, it is apparent that the onus for innovation falls on the entrepreneur himself or herself. Take for instance, the fact that, of the barriers to innovation listed in Section 4.7, the vast majority were 'systemic' in nature. However, in Section 4.8, which dealt with 'enabling factors' for change, most were *personal* in nature. Klerkx & Leeuwis (2008b, p. 260) note that in the current literature, commercialising a product, process, service or business idea requires an "active attitude" towards innovation, implying that responsibility for innovation does indeed lie with the entrepreneur or firm. As such, policy measures targeting barriers to entrepreneurial activity should recognize the need to improve entrepreneurialism where possible – innovation intermediaries (see below) have also been promoted to aid entrepreneurs access suitable knowledge (Klerkx & Leeuwis, 2008a). An apparent imbalance between, on the one hand, the AIS emphasis on *systemic* issues and, on the other, the emphasis of this research on *personal* enabling factors for innovation, may suggest further theoretical work is required (see Chapter 6).

Certain systemic mechanisms to bolster entrepreneurial activity are suggested in the relevant literature. Innovation intermediaries, organisations that sit amongst and facilitate interaction between third parties (see below), can counter *weak network failure* for example (see Lamprinopoulou et al., 2012). However, given the intense competition between certain firms in the fresh produce industry, it can be assumed that some knowledge will remain proprietorial (even in instances where cooperation, perhaps facilitated by an intermediary, could reduce other project costs).

It is clear that retailers can and do play a prominent role in innovation. In their investigation into how retailers foster (or not) eco-innovation in dairy, beef and bread supply chains, Mylan *et al.* (2014) show the varying degrees to which certain sectors are supported with respect to innovation: whilst dairy production has seen significant investment through favourable contractual arrangements and economic incentives, the situation in beef production is notably different, marked by an "adversarial" relationship between supplier and customer. It may be the case that different fresh produce sectors have similarly variable relationships with their customers. Based on these comparisons, Mylan *et al.* (2014, p. 27) suggest that:

… enhanced supermarket involvement in distributed eco-innovation requires a shift in supply chain governance modes and the effective use of innovation coordination mechanisms: economic and information-exchange modes may need to be complemented with more subtle modes of governance, such as the collective framing of sustainability issues and the development of shared visions that reduce uncertainty and provide clarity in the orientation of eco-innovation."

Such measures echo the words of one interviewee (Section 4.7.1.3) who lamented the lack of supply chain support from supermarket customers. The need for – and benefits of – a 'shared vision' are discussed below, but it is worth noting here that a number of UK-wide 'roadmaps' (2008, 2010, 2015) have been developed for the dairy industry that offer a guide to the sustainability measures being introduced in that sector. At the same time, improving information-exchange between suppliers and customers may help remedy the *weak network failure* identified above; again, of those sectors included in Mylan *et al.*'s research, the greatest level of information-exchange between suppliers and customers occurred within the dairy supply chain.

It is more difficult to envision a means of fostering greater trust – considered a vital component in innovation both on the grounds of previous research and through the evidence presented in Chapter 4 of this project – between actors that view each other in an adversarial way. A known weakness of the AIS framework, for instance, is the assumption that there are common goals or foci within an innovation system (Klerkx et al., 2012b, p. 464), which is not necessarily correct and may represent an area for improvement in the approach.

Capability failures may be countered by improving the availability of venture/risk capital, as proposed by Turner *et al.* (2015a). However, several participants in this project referred to accessing funding from the European Union *Fruit and Vegetable Regime* through involvement with a producer organisation (see Section 4.5.3). This mechanism matches 50% of pooled P.O. funding from members to facilitate innovation in a number of areas (*ec.europa.eu*, n.d.). As such, systemic instruments that help producers access existing funding mechanisms are preferential. However, producer organisations – one example of the increasing vertical integration of the entire agricultural sector – can also facilitate entrepreneurial activity through enhanced knowledge sharing. As Young & Hobbs (2016, p. 431 pp. 431) note:

"… closer vertical linkages with processors may provide producers with access to additional information about the requirements of consumers, thereby enhancing the flow of market information back down the supply chain."

The effectiveness of such associations in fostering innovation through knowledge exchange is clear – P.O.s can also reduce uncertainty by offering in-house agronomic advice and providing access to known or registered brands for which there is already a market (see Section 4.6.1.2). However, a risk associated with pushing growers into one P.O. or another is *strong network failure*, discussed in Section 4.6.1.2 (and below), which may already be apparent in UK fresh produce.

5.2.2 Knowledge development

In line with Turner *et al.*'s (2015a) description of the *knowledge development* function of AIS, knowledge is developed by both formal and informal processes; it is clear that knowledge development in the fresh produce industry is no different in this respect. However, the strong emphasis on 'overseas' sources of knowledge that characterises innovation in the UK represents a potentially important contribution to the study of AIS. Focusing on 'global innovation networks', (GINs) Herstad *et al.* (2014) note that the search for knowledge has taken on a worldwide dimension, with the locus of innovation shifting from individual firm to the wider, distributed networks in which they sit; the flow of information between 'epistemic' communities facilitates partnerships and collaboration, which suggests that the notion of 'sector' remains important (see Liu et al., 2015; Pavitt, 1984; Thitinunsomboon, Chairatana, & Keeratipibul, 2011 for example). It is possible that, for many countries, an AIS is now a GIS, a concept that is gaining traction in *Innovation Systems* research (see Binz & Truffer, 2017). As Metcalfe (2007, p. 442) notes:

"… these [innovation] systems increasingly transcend national boundaries and increasingly call into question the idea of isolated national innovation policies…"

The significant emphasis on 'learning by doing' (Section 2.2.5) found in the UK fresh produce industry is mirrored in the *innovation systems* literature. Indeed, at the heart of systems thinking is a focus on learning processes (Carlsson et al., 2002). Interaction and experimentation with a product or process – 'know-how' or "experience-based-knowledge" – is a key source of innovation. As Herstad *et al.* (2014) point out:

"Innovation takes place mainly through the application or novel combination of existing knowledge from various scientific and non-scientific sources, often in response to the need to solve problems that arise when customers and suppliers interact. Knowledge is created more often in an inductive process of testing, experimentation and other forms of 'situated' practical work."

However, there are factors at work in today's fresh produce industry that serve to impede such processes.

5.2.2.1 Barriers to knowledge development and mechanisms for change

As identified in Chapter 4, a number of barriers exist in terms of knowledge development. Fragmentation, for example, constitutes a barrier to knowledge development and its subsequent diffusion (see next section). The privatisation of previously public extension services and creation of "knowledge markets" is associated with fragmentation (and linear thinking about the sources of innovation) (Leeuwis, 2000).

A lack of vertical coordination has led to a situation in which a number of organisations undertake research programmes with little or no coordinated oversight, and in the name of different innovation agendas (what Weber & Rohracher, 2012 might call policy coordination failure). It may not be coincidental that, at the same time, there is discernable lack of unifying 'vision' for the industry (see Section 5.2.4). The assertion that "everybody's sort of doing their own thing" (Section 4.7.1.1) reflects a deficit of coordination mirrored in other studies (Hermans et al., 2015). It is likewise exemplified by the diverse advisory community that has emerged following the privatisation of public extension services in England (Hermans et al., 2015; Klerkx & Proctor, 2013). An issue of this nature can be cast as either a problem of *capability* (none of the existing institutions are able to coordinate action at the desired level or have such a mandate) or *presence* (the lack of an institution to coordinate action). However, in contrast to the situation found by Turner *et al.* (2015a) in New Zealand, the government *is* seen as a participant in knowledge development (through UK Research Councils). Hekkert *et al.* (2007) suggest that three factors determine the strength of this system function: 1) R&D projects, 2) patents and 3) investment in R&D. However, it is clear that the problems associated with knowledge development in the UK fresh produce industry go beyond these simple metrics. Matching the supply and demand of adequate knowledge for innovation, for example, is a central concern in AIS research (Klerkx & Leeuwis, 2008a; 2008b; Leeuwis, 2000). A range of systemic factors complicates this process in UK fresh produce:

1. Demand-side knowledge development is administered through sector-specific levy board steering groups, providing immediate (and somewhat democratic) relevance at the expense of strategic, cross-sector, pooled projects. As such, duplication of knowledge is a risk (also observed by Sutherland et al., 2013 in the UK context); it also signals a divide between long- and short-term thinking that some suggested prevented steps being taken to address growing problems (such as the withdrawal of certain crop protection products). It was not suggested that the levy organisations fail to capture the needs of the industry in the short term; in fact, it was the *reactivity* of the levy board to the immediate needs of the grower base that was invoked as a problem (Section 4.2.5). As such, this corresponds to a *quality* issue, for whilst provisions are made to capture research needs through the aforementioned panels, how well this meets future and present demands is subject to question.
2. Adequate *demand articulation*, and the wider issue of a lack of shared language between different actors and professions (see 4.7.1.2 and

4.2.3), can complicate the process of provisioning client-orientated knowledge development, which Klerkx & Leeuwis (2008b, p. 261) cite as a problem of increasingly 'closed' knowledge infrastructures (see Section 2.4.1). Weber & Rohracher (2012, p. 1043) call this *demand articulation failure,* where there is a deficit in anticipating and learning about user needs. In AIS literature this type of problem is generally given to be one of *presence*; i.e. there is a lack of intermediary organisations to facilitate the effective diagnosis and analysis of problems and subsequent articulations of latent (farmer) needs (Klerkx & Leeuwis, 2008b). However, the levy organisations are in place, in terms of both provisioning research and its subsequent delivery, to oversee issues relating to demand articulation: as such this becomes less an issue of *presence* but *quality*, and one which must be discussed with reference to wider, strategic issues (see below).

3. *Divergent innovation agendas* affect the development of knowledge; as noted in Section 4.7.1.2, the development of knowledge through formalised processes is subject to questions of fairness, due to larger organisations, by virtue of having sometimes significantly greater resources, influencing sectoral innovation agendas (see Klerkx et al., 2006, p. 191). In essence this reflects the wider issue of "contested agronomy", discussed in Section 2.4, but at a national, rather than global scale. Considering the importance, where innovation is concerned, of research 'relevance' (EU SCAR, 2012, p. 7), one explanation for the dismissal of certain technologies or processes by growers is that they are simply not relevant. As Röling (Röling, 1988, p. 4) claims: "Diffusion of an innovation can only take place within a

‘population’ of intended utilisers who face similar production conditions”. In Chapter 4 (Section 4.8.4), this was described as the “fit” of a particular product or process. The divergent innovation agendas of today’s fresh produce industry, and the disparities in scale and sectoral needs, ensure that this ‘population’ requires knowledge of different sorts. Not a failure of any particular type *per se*, these differing innovation agendas call for the identification of common problems, noted by some participants as “safe space” for the levy organisations (see Section 4.2.3).

4. When it comes to *translation* of research – at whatever stage it is required – there is a notable lack of formalised processes for achieving this aim: as with other contemporary issues, translational activity appears to have suffered from the privatisation of formerly public research and extension services. However, even though key institutions may no longer be in public hands, many of the individual actors associated with the movement of new knowledge through the innovation system, such as agronomists, remain important nodes in this process. The problems associated with translation can be classed on the one hand as *market failure*: the knowledge market created in the wake of the privatisation of public advisory services has not seen the appropriate mechanisms develop to carry out this task. On the other, it is a problem of *capability*: institutions charged with provisioning and delivering research activities have not developed robust mechanisms for systematically capturing the value of new knowledge. Instead, at the present time these tasks fall on individuals who are able to match the needs of growers with existing knowledge (in the case of agronomists) or perceive the value in translating

existing knowledge into new avenues of interest (in the case of scientists).

5. A further potential barrier to knowledge development – and perhaps the most simple explanation for any impaired functionality – is reduced public funding for agricultural research (see Section 4.7.1.2), which has led to increased competition and insecurity, working against those conditions that permit collaboration and social learning (Hermans et al., 2015). In contrast, authors such as Pardey (2006) note that, barring India and China where investment in agricultural R&D has sharply increased, developed countries remain the dominant funders of agricultural research, the UK being a 'top 10' investor. Quite what this means for UK agriculture, where innovation frequently originates overseas, is not clear, but it does suggest that the primary barriers to innovation are not (solely) in levels of investment – at least not for agriculture as a whole – but in their manner of delivery/funding mechanisms (see Klerkx & Leeuwis, 2008b for example). As such, this is likely a problem of *quality* rather than presence.
6. The internationalisation of knowledge development and diffusion is not a new phenomenon, nor is it a "failure" in any particular sense; that innovation support services remain primarily domestic concerns (see Hermans et al., 2015; and Lamprinopoulou et al., 2012 for example) might be classed as an *institutional* or perhaps *infrastructural* failure of *presence*.

How might these interlocked issues be addressed? In AIS literature, improving the function of 'intermediary organisations' is a suggested solution to many demand-side problems (intermediaries are explored in more detail below). However, there are other institutional mechanisms that can be brought to bear on problems associated with knowledge development:

1. *Innovation platforms* (IPs): these act as a means to bring different stakeholders from a particular sector together to "enable transformative change" (Klerkx et al., 2013, p. 185). As Klerkx (2013, p. 186) notes, these are deliberate interventions "… to create a support network that can foster an effective combination of technical, social, economic and institutional innovations". Most AIS literature concerning IPs is based on work in the developing world (Kilelu et al., 2013; Schut et al., 2015), but they are already considered viable models for change in the UK (UK Government, 2014). Indeed, as alluded to in Section 4.6.1.3, the HAPI programme is a current programme that coordinates far-reaching research themes across crop types. However, HAPI is primarily a technical programme – perhaps properly referred to as a technology platform – and runs the risk of 'missing' other stakeholders. On the other hand, the Horticulture Innovation Partnership (Horticulture Innovation Partnership, n.d.)[16], established in 2013 has sought to act as a platform for interaction amongst various actors in the industry. A further strength of IPs is providing a platform for 'champions' – key informal enablers of change (see Section 4.8.2.3) – to influence others

[16] Despite being identified here as an important innovation platform, the HIP's future is not certain, perhaps representing the difficulty in sustaining such initiatives.

and promote innovation (Klerkx et al., 2013). IPs will invariably have to target areas of *common* concern; the *Innovation for Agriculture: Soil & Water programme* ("Soil and Water," n.d.) is a good example of a national innovation platform that targets common problems – and while IPs are more common at local or regional levels elsewhere, it has been acknowledged that the local and national institutional environment are intimately associated (Hounkonnou et al., 2012). One means of facilitating and assessing the impact of IPs is to have doctoral researchers measure project outcomes and constraints (Hounkonnou et al., 2012), which may also be a means of encouraging researchers to engage with industry (cited as a problem in Section 4.7.1.2). The involvement of various stakeholders in IPs could also serve as a means to provide those stakeholders with the non-obvious benefits of cooperation (i.e. the ability to improve the practicability of proposals and access to otherwise hidden information (see Section 4.8.4). However, as noted above, if the onus to cooperate in research programmes falls on the entrepreneur himself or herself, then engagement remains a voluntary act and, as such, is subject to uneven levels of capability (see Section 4.8.2.2). IPs can and already appear to be combatting the vertical fragmentation caused by the loss of public extension services, by providing some level of functional *capability* and *presence*; they may also serve to unite disparate actors with different innovation agendas around common problems.

2. As noted previously (see Sections 4.5.2 and 5.2) learning by doing is a key source of new knowledge. Making "new insights explicit", as Leeuwis (2000) dubs it, requires experimentation with on-farm

operations. However, considering the complexity of most farm businesses, and the multitude of possible explanations for observed phenomena, making insights explicit is troublesome. Several solutions to this problem exist:

a. *Learning in groups*: one means of triangulating on the exact cause of phenomena is to compare it by talking with people who have similar experiences (i.e. peer groups). A number of examples of this already exist in the fresh produce industry (and wider UK agricultural community). *Innovative Farmers*, for example, UK-based project aimed at bringing together farmers from across the country to set up “field labs” in which citizen (or, rather, “farmer”) science can take place (Soil Association, n.d.). Likewise, study tours – shown in Section 4.5.1 to be very effective at facilitating the development (and spread) of knowledge – are frequently organised by the levy organisations, producer organisations and the larger grower businesses themselves. Not only do these tours provide a means of knowledge exchange and chance to interact with new systems of agricultural practice, but represent the increasingly internationalised nature of knowledge development and exchange. Such measures also facilitate network building, which is important in its own right but may also give people the opportunity to meet *champions*.
b. *Feedback and data collection*: considered a key component in *systems* studies, the idea of feedback is important when conducting experimentation (in both formalised science and on farm). It is a stimulus for reflection, and can be compared

with data from other sources to draw conclusions about certain management practices, for example (Leeuwis, 2000). Indeed, better scrutiny of data and feedback is considered a means of improving research orientation (see Section 4.7.11).

c. Leeuwis (2000) notes that farmers and horticulturalists can only contribute to knowledge development if they are stimulated, challenged and supported, reflecting observations in Section 4.8.1 that 'challenging' others to innovate was a means of stimulating action. As Hermans *et al*. (2015) note, "… creativity and innovation are stimulated by cooperation and active exchange of ideas and this forms the basis for the concept of social learning".

3. Given the international nature of knowledge development today, there are emergent challenges for the domestic knowledge infrastructure of the UK, where for certain firms and networks national boundaries no longer apply. Although globalising trends are not new, the nationally-limited organisations tasked with supporting British agriculture must somehow meet the needs of increasingly divergent innovation agendas (a situation made more complicated by the UK's impending departure from the European Union and the uncertainty this brings to the nature of future European collaboration). A good deal of attention has been paid to *national* systems of innovation (Freeman, 2000; Lundvall, 2007), but in instances where one particular sector is under scrutiny, it is perhaps more prudent to let the influences on that system define its boundaries, rather than letting national limits serve as an (increasingly) arbitrary boundary. Some have considered *regional*

systems of innovation to be a more appropriate frame for the study of innovation systems (Asheim & Gertler, 2005; Cooke, 2001). Likewise, there is a good deal of literature concerning the multinational firm in innovation (Cantwell & Molero, 2003), but much less concerning how the domestic innovation infrastructure can support or cope with this arrangement; one possibility is to create new forms of cross-border partnership between regional innovation support systems. However, of the work done in this area (Makkonen & Rohde, 2016) the focus is on cross-border scientific collaboration rather than, say, intermediary organisations (see below) or extension services, which remain a domestic concern.

4. In terms of translation, very little research has been undertaken within the agri-food sector, barring Pollock's (2012) call for more effective translation of research along the R&D "pipeline" and a RAND Europe technical report *Translational Research and Knowledge in Agriculture and Food Production* (Wamae et al., 2011) funded by BBSRC and Defra that explores how best to assist in the translation of research outcomes into practical applications. Interestingly, this report also concluded that the LINK schemes were viable vehicles for the translation of research (Section 4.6.1.3). It also concludes that issues related to communication and fragmentation, as in this project, contribute to problems relating to translation and though not cited as a barrier to translation, neither does the report discern any robust, formalised processes within the research domain for translational activities. As such, many of the suggested measures to enhance translational activity – at various stages – are the same as are proposed in this research, namely:

a. *Academic incentive structure*: stimulating and rewarding translational activity (that is aligned with industry needs) through incentives can improve upstream "knowledge transfer activities" to help correct *market failure.*

b. *Joined-up policy*: this essentially mirrors the "guidance of the search" function of innovation systems explored below, by calling for a more clearly articulated national vision for agriculture in general (though it is not clear precisely how this fosters translation itself).

c. *Strengthen interaction amongst key actors*: improving the level of interaction between actors in the AIS will help to ensure that *information asymmetry* (discussed above) does not impede opportunities for translation; translational activities, where they occur at all, rely to a large extent on networked interactions (Section 4.8.2.3). In particular, and as recognised by staff within the levy organisations, stronger mechanisms must be in place to ensure that areas of potential overlap are not overlooked by the separate sectors that make up the fresh produce industry when allocating research funding. Doing so may increase translational *capability*, though it would also rely on having the expertise in place to provide an understanding of the potential for cross-sector translational science. A further factor that hampers the translation of science between crop types is the relative size of certain horticultural sectors (Section 4.7.1.3).

> Certain structures developed by the National Institutes of Health (NIH) in the United States, with the express goal of taking basic science discoveries to the 'bedside', may also be worthy of consideration (see Menary, 2015). For example, institutions devoted to this endeavour, such as the National Centre for the Advancement of Translational Science (NCATS, established in 2011), have been formed. However, medical research receives far more in terms of funding than agri-science, making the suggestion that such institutions could be created for the agri-food system seem unrealistic; so too the onus on best practice, which, although perhaps desirable in the agricultural domain, is more developed in the health domain (due to 'duty of care') and complicated by the markedly different environmental circumstances found on farms. However, the importance of champions (of specific technologies) is no less important in either field (Menary, 2015).

5.2.3 Knowledge diffusion

In line with Turner *et al.*'s (2015a) description of the *knowledge diffusion* function, knowledge diffusion in the fresh produce industry relies on networks, both personal and professional. Several platforms facilitate such networks, such as producer organisations and grower groups, levy board panels and steering groups, peer networks and strategic partnerships with foreign firms. It is also clear that digital networks, such as social networks, are becoming increasingly important as a means of knowledge diffusion for growers (see Section 4.8.4). As knowledge moves through these networks it is further developed through adaptation and application to different circumstances. A clear example of this – and of innovation "scaling up" and "out" – in the fresh produce context is the development of polytunnels and 'attendant', supporting innovation (mapped comprehensively by the National Horticulture Forum (2011b)).

5.2.3.1 Barriers to knowledge diffusion and mechanisms for change

As Klein-Woolthius (2005) observes:

"… a range of factors such as inappropriate structures and institutional or capabilities barriers may negatively influence the spread or direction of processes of innovation and knowledge exchange"

Indeed, a number of barriers identified in Chapter 4 involve the diffusion of knowledge. As noted above, a key theme dominating discussion of both knowledge development and diffusion is the transition to a "pluralistic advisory system" and the fragmentation this has engendered (Sutherland et al., 2013). The commoditisation of knowledge has thrown up several problems related to the delivery of knowledge, as Sutherland *et al*. (2013, p. 97) note:

"Concerns have been expressed about the profusion of agricultural advice providers in England resulting in a lack of coherence and co-ordination. This fragmentation results in: duplication among providers; gaps in provision; information overload; confusion; contradiction and even misinformation to farmers. These problems are exaggerated when advisors are pursuing multiple, and sometimes competing, goals."

However, England is not alone in this respect: Hermans *et al*. (2015) have found that, of eight different European AIS, several have made or are making the transition to pluralistic (and often private rather than public) advisory services. Hekkert *et al*. (2007, p. 423) suggest that this system function can be assessed by mapping the number of conferences and workshops devoted to a particular technology group, and mapping network sizes and intensity. It was felt that with the loss of public extension services came a reduction in the amount of fora for communication (Section 4.6.2) (though a more robust count of relevant conferences and workshops might provide clarity on this issue). However, as Kash & Rycroft (Kash & Rycroft, 2002, p. 603) point out "… a central, but frequently unrecognized characteristic, of our world of repeated innovations of complex technologies [is] the requirement for *self-organizing* networks" (author's emphasis). Perhaps then, the focus should be on how these networks organise, and what holds them back, rather than simply their size or intensity. Several such barriers have been identified in Chapter 4:

1. *Loss of funding and facilities*: Hermans *et al*. (2015, p. 43) explain that England "… has seen a concentration of (dedicated) research institutes over the last thirty years", with very few independent institutes left. At the same time, the country has seen increasing cooperation between the agri-food industry and universities, although this does not appear to have altered the impression amongst industry experts that funding has been "stripped away" (see Section 4.7.1.2). In turn, this situation has diminished some possibilities for interaction and corresponds to an *infrastructural*

failure of *presence*.

2. *Cognitive gaps*: one barrier to knowledge diffusion appears to lie with what Klerkx calls "cognitive gaps" (see Section 4.7.1.2), in which actors from different institutional backgrounds – and perhaps one can add to that professional and sectoral backgrounds – have "… too much cognitive distance to adequately learn together… or have different norms, values and incentive systems which hinder effective communication" (Klerkx & Leeuwis, 2009, p. 850). In particular, it is the differences in these norms, values and incentives that prevent researchers and the grower base from seeing 'eye to eye', meaning that researchers are not always best placed to engender knowledge diffusion. However, as described in Section 4.6.1.1, trustful, working relationships between researchers and growers can be extremely beneficial to innovation, highlighting the importance of bolstering such connections (see A. Hall, 2007). Influential researchers, in these cases, might be considered *champions* in their own right. As Oreszczyn *et al*. (2010) suggest, the importance of informal networking may have increased where centralized coordination has diminished. A problem of this type is likely to be dubbed one of *quality*: interaction does occur (i.e. *presence* is not the problem) but is hampered by lack of mutual understanding. A further issue relates to the incentive systems mentioned above: the nature of research funding – and academic strictures in general – favours project-driven, finite programs that may not include seeing the fruits of that science realised in practice (see Section 4.7.1.2). Of course, the practical "gap" between science and grower base was once the domain of public extension activities. However, routes to impact are

now more multifarious and intractable. Klerkx *et al*. (2006) also described output-orientated contracts as "rigid", with little room for maneuver, in contrast to the true, unpredictable nature of innovation 'on the ground'.

3. *Horizontal and vertical fragmentation*: this impedes the rate of diffusion by placing barriers to knowledge exchange – as shown in Sections 4.6.1 and 4.8.1, functioning networks are vital to the spread of information and, thus, the raw ingredients for innovation. Klerkx & Proctor (2013) find that fragmentation has led to problems for land managers in composing the right networks and obtaining adequate knowledge; likewise, information asymmetry prevents the establishment of otherwise suitable partnerships (see Section 5.2.1.1).
4. *Loss of expertise*: the gradual loss of expertise through retirement – without adequate succession planning – and retention of knowledge over time presents a barrier to the continued spread of the knowledge that individuals and particular institutions may hold. A secondary effect associated with this loss is duplication of research. In the former case, this is a problem of *absence* (of certain actors) and in the latter, an *institutional* problem related to either the *absence* of suitable mechanisms to store past research or perhaps their *quality*. One possible remedy to this problem is to establish or improve databases in-line with Klerkx & Proctor's (2013) suggestion for centralised networks (see below).

A common solution to problems of this kind – and also those problems associated with the development of knowledge – is to examine the role and functioning of so-called intermediary organisations, which are positioned to operate in the midst of such issues.

5.2.3.1.1 Intermediaries

Klerkx & Leeuwis (2008b) point to the dismantling of the Dutch extension service as the catalyst for the development of "intermediaries", or any organisation that "… functions in the midst of the users and producers of knowledge" (Smedlund, 2006, p. 210). In more specific terms, Howells (Howells, 2006) defines an innovation intermediary as "… an organisation or body that acts an agent or broker in any aspect of the innovation process between two or more parties". The respective governments of the Netherlands and England both chose to 'liberalise' their formerly public extension services at the same point in time and have notable similarities in terms of blocking mechanisms for knowledge diffusion (Hermans et al., 2015). Indeed, many of the problems associated with knowledge diffusion appear to stem from this decision, though even in countries maintaining strong public extension services – such as France and Italy – problems associated with knowledge diffusion persist. Not only are intermediaries a significant focus within the AIS literature (see Klerkx & Leeuwis, 2008a; 2008b; Polzin et al., 2016) but have become, in one form or another, an important factor in the dissemination of knowledge in the UK fresh produce industry (though seemingly less studied than their Dutch counterparts). Klerkx & Leeuwis (2008b) delineate the main functions of intermediaries:

1. Demand articulation
2. Network brokerage

3. Innovation process management

Each of these tasks is explored below in further detail. It is also worth noting that intermediary organisations can operate at different levels of aggregation in the AIS: from targeting the individual entrepreneur, collectives, heterogeneous networks of actors, to whole supply chains. Likewise, some intermediaries focus on certain sectors, and some operate across different agricultural sectors. Such organisations can be public or private, and as Howells (2006) points out, take many forms, including research councils.

5.2.3.1.2 Demand articulation

Through the creation of agricultural knowledge markets, extension service provisioning has become demand or client-driven, as opposed to supply or provider-driven (Klerkx et al., 2006, p. 190). In turn this enhances the need to ensure that client needs are properly understood and articulated to appropriate parties; without clear demand, it is difficult for knowledge systems to be, in truth, client-orientated (Klerkx & Leeuwis, 2008b). Some degree of concern was expressed about the ability of current mechanisms to adequately capture the more immediate industry needs (Section 4.7.1.2). However, it is the longer-term issues that appear to have escaped articulation, with calls from growers, agronomists and levy organisation staff to operate at a more strategic level (see Section 4.2.5).

Here, intermediary organisations can facilitate the "creative process" to generate a strategic innovation plan that encompasses both real needs and avoids "blind spots" (Klerkx & Leeuwis, 2008b). Paired, perhaps, with a more all-encompassing, coordinated 'vision' for the industry (see 'Guidance of the Search', below) a strategy can be developed to satisfy both the near-term and longer-term needs of the industry. Klerkx and Leeuwis (2008b) point us to Van der Meulen *et al*. (2003), who suggest that Science and Technology Foresight (STF) can be used to determine long-term science and innovation policy.

5.2.3.1.3 Network brokerage

The importance of networks in terms of knowledge diffusion has been highlighted in Section 4.6.1. Hekkert *et al*. (2007, p. 423) contend that "… network activity can be regarded as a precondition to 'learning by interacting'". A study by Pannekoek *et al*. (2007) found that most innovative ideas in Dutch horticulture came from a firm's networks and relations. As such, network *formation* is a key concern for innovation. Intermediary organisations can facilitate this by providing fora for various system actors to interact (Howells, 2006), transparency in R&D and "knowledge-intensive business services" (KIBS), and help firms discover financing opportunities and by subsidising innovation activities (Klerkx & Leeuwis, 2008b).

Social capital is another concept that is important here: Klerkx & Proctor (2013) describe social capital as the features of social organisation in a given system, such as its networks, its level of trust and the norms of reciprocity and mutual aid that mediate collective action. In the fresh produce industry, the picture of social capital is fuzzy: a small, tight-knit community of peers is described on the one hand (Section 4.2.1), whilst a highly divergent, defensive culture is portrayed on the other (Sections 4.2.1.1 and 4.7.1.5). It is possible to explain these differing perceptions by comparing different “types” of social capital (Table 10).

Table 10 Typology of social capital, adapted from Klerkx & Proctor (2013)

Type of social capital	Main features
“Bonding”	• Trusting, cooperative and dense networks • Similar social-demographic characteristics • Strong, informal ties • Long-term reciprocity
“Bridging”	• Links between separated (but dense) networks • Larger, looser networks • Weaker ties • Formalised collaboration • Weaker trust
“Linking”	• Trusting relationships across explicit, formalised power or authority gradients in society • Lack of similarities in terms of socio-demographic • Characterised by norms of respect

A further distinction lies between networks themselves, and their use depends on the precise needs of the knowledge exchange in question. For example, *centralised* networks are adequate for maintaining enough operational knowledge for “routine problem solving” in a well-known solution space (Smedlund, 2008). On the other hand, *distributed* networks are those that resemble a *community of practice*, a network of peers who share tacit knowledge through both formal and – importantly – informal gatherings. A network of practice is a looser collective of people, connected less by a similar profession but joined by a mutual problem (Klerkx & Proctor, 2013). A *decentralised* network, however, is one in which combines with individuals outside of established communities or networks of practice for the purposes of attaining new knowledge (Smedlund, 2008). As Klerkx & Proctor (2013, p. 16) state:

"Because a decentralised network involves contacts with people which are outside the established [communities of practice] and [networks of practice] of advisors, and there may be boundaries in terms of culture, language, work procedures, often so-called boundary spanners or brokers are needed to exploit such weak ties and create linking social capital." (see also Klerkx & Leeuwis, 2009; Oreszczyn et al., 2010)

The AHDB-organised "SmartAg" conference (AHDB, n.d.) is a recent example of attempts to link diverse professions for this purpose. One can speculate on both the type of network and extent of social capital that participants have described based on the kinds of barriers to knowledge development they have encountered. It may be a lack of *bridging social capital* for example, that prevents knowledge being delivered to the "hard to reach farmer"[17], who resides in a dense network of his or her own peers. In

[17] Some commentators reject this term entirely (see Jansen, Steuten, Renes, Aarts, & Lam, 2010).

instances where a participant has described a close-knit, reciprocal community of individuals connected by common causes, it is likely they are part of more trusting professional and informal networks. For others, who feel that their relationships with other industry actors are purely "transactional", a weaker, more formalised form of social capital is evident.

Of course, an individual can operate across different networks, each with different types of social capital, depending on the demands of a particular problem (Klerkx & Proctor, 2013, p. 23). As such, intermediary organisations can contribute to network formation by taking account of the "types" of networks required to solve a particular problem and targeting the appropriate "space" for intermediation.

Klerkx *et al*. (2009) suggests that "… the effective evaluation of innovation brokers would require the development of indicators to measure 'soft' processes like network formation and institutional linkages emerging in the context of innovation and both qualitative and quantitative evaluation methods". Such an approach would also be in-line with Hekkert *et al*.'s (2007) criteria for assessing the strength of the knowledge diffusion function in a given system (see above).

5.2.3.1.4 Innovation process management

As Izushi (2003, p. 771) claims, "where there is a wide gap between suppliers and users of technology in the process, there have been appropriate intermediary agencies that connect them". Intermediaries, then, organise and manage the networks that make innovation possible, bridging cultural and cognitive differences between different knowledge domains, acting as "knowledge brokers" – much like extensionists – but also fulfilling functions such as implementation, intellectual property protection, and commercialisation of innovation outcomes (Howells, 2006; Klerkx & Leeuwis, 2008b).

5.2.3.2 Intermediaries in the Fresh Produce Industry

It is clear that intermediary organisations can perform much needed brokerage functions in an innovation system, but this begs the question: where are the intermediary organisations in the fresh produce industry? In the Dutch case, intermediaries have proliferated in the wake of privatization of public extension services (Klerkx & Leeuwis, 2008a; 2008b; Van der Meulen, Nedeva, & Braun, 2005). However, in the UK it may be more accurate to suggest that intermediary functions are carried out by many different organisations, none of which can be defined solely by this activity: no one organisation is capable of carrying out all necessary intermediary processes, yet many have remits that extend into intermediary functions, and sometimes significantly so. As such, there may be limited opportunities for other intermediary organisations to form (such as those described by Klerkx & Leeuwis, 2008b) – though a number can be identified. As Lamprinopoulou *et al*. (2012) find in the case of Scotland, and as this study corroborates in the English context, intermediaries have developed (or not developed) along a different trajectory to elsewhere.

In many respects the AHDB does perform the types of activities associated with intermediary organisations; established following the privatization of public extension services to correct for expected market failures, it commissions industry-focussed research, extension activities (knowledge brokering) and network formation[18]. Indeed, many of those tensions identified by Klerkx & Leeuwis (2008b) in the Dutch context have been described by participants in this research with respect to the levy organisations in the UK. For example, the *invisibility and immeasurability of service value* poses a problem for both intermediaries in the Netherlands and in England, where the true sources of knowledge can be "masked" by appropriation (see Section 4.5.4). Likewise, *unclear images of innovation intermediaries* (i.e. what their precise functions are) due to operational overlap with other knowledge-intensive organisations have been noted as problematic (Howells, 2006). The *lack of coherent policy* between regional intermediaries is also evident. A further problem we might add – perhaps because of its inherently "public" character – is greater ability of certain firms to influence sectoral innovation agendas (Section 4.2.3), which Klerkx (2008b) calls *progressive client bias*, where intermediary organisations focus on those entrepreneurs that already possess the means to innovate. Interestingly, overreach by public intermediaries and, conversely, their overly limited mandates, are both problems affecting such organisations elsewhere (Klerkx & Leeuwis, 2008b).

In England, the levy organisations remain prominent enough to undertake the work of what is now – in the wake of the dissolution of the Dutch equivalent – tens of intermediary organisations in the Netherlands. The levy

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[18] Howells (2006) calls such organisations "knowledge intensive business services" firms (KIBS).

board likewise sits apart, in terms of funding structure and certain aspects of its remit (like market formation), from “pure” intermediaries.

Other organisations undertaking intermediary activities include the increasingly dominant producer organisations – and certain large firms – that act as progressively centralized networks in themselves, with a high degree of trust (see Yang, Klerkx, & Leeuwis, 2014). One risk of such an enterprise is *strong network failure*, in which knowledge is locked ‘out’ as much as ‘in’ (see Section 4.6.1.2 and Weber & Rohracher (2012)), which can lead to institutional “lock-in” in which new, potentially beneficial innovations are prevented from having impact within the group by current thinking (Hogeland, 2015). Yet these networks disseminate knowledge through in-house agronomists (knowledge brokering) and also broker new network arrangements through strategic partnerships with other businesses, sometimes overseas-based firms. By linking their growers to funding opportunities, they are also providing innovation process management. A number of those platforms described in Section 4.3.1 likewise fulfill similar roles, acting as nodes for knowledge exchange and network formation (HIP) or innovation process management (Innovative Farmers).

In light of the situation described above, it is fair to say that where gaps exist in the provision of knowledge development and dissemination in the fresh produce industry, they are to greater and lesser extents being filled by new intermediary mechanisms (though these are not necessarily formally aligned in any way). However, the operations of the levy organisations remain such that they undertake significant intermediary functions without the remit or resources to handle the national capacity for all research and development needs at once (Brian Jamieson & Associates, 2008). Interestingly, tensions over the levy board's remit (Section 4.2.3) lie at points that differentiate it from a "pure" intermediary organisation.

The important role of intermediaries reflects the transition from "linear" thinking about the nature of agricultural innovation, with a move towards "systemic facilitation", encompassing the resolution of communication problems between groups – and not only between science and practice (Klerkx, Schut, Leeuwis, & Kilelu, 2012a).

5.2.4 Guidance of the Search

Creating a 'guiding' vision for the innovation system helps to orientate other systems functions, such as knowledge development and entrepreneurial activities. In essence, this refers to any activity that improves the "… visibility or clarity of specific wants among technology users" (Hekkert et al., 2007, p. 423).

5.2.4.1 Barriers to guiding the search and mechanisms for change

Hermans *et al*. (2015, p. 47) find that "visions" on agriculture have become fragmented in a lot of (European) countries. The simultaneous demands put upon the agricultural sector – from conservation to rural development – have pulled it in multiple 'directions'. Here, too, the vertical fragmentation discussed in Section 4.7.1.1 diminishes coordinated action at a national level, with different public bodies seemingly pursuing their own innovation agendas. Taking a Multi-level Perspective Weber & Rohracher (2012, p.

1041) stress that to be concerned with change is to also be concerned about the "direction" of change. As such, the authors complement the systemic failures outlined by other authors (Hekkert et al., 2007; Klein Woolthuis et al., 2005) by adding another, *directionality failure*:

"Transformative change… is intimately linked to the question of direction and requires the setting of collective priorities; priorities that require a strategic policy approach to be in place. We therefore suggest an additional type of failure, namely directionality failure. It points to the necessity not just to generate innovations as effectively and efficiently as possible, but also to contribute to a particular direction of transformative change. This direction is defined, for instance, by the identification of major societal problems or challenges, for which solutions need to be developed with the help of research and innovation." (Weber & Rohracher, 2012, p. 1042)

What are the problems associated with directionality failure?

1. The liberalisation of extension services in some countries – including England – has led to the loss of an important (national) steering mechanism for the AIS (Hermans et al., 2015), as well as fragmentation. Those bodies that do exist do not necessarily share a coherent view of innovation (see above). As such, this is an *institutional* problem of *presence*.
2. As Turner *et al.* (2015a, p. 8) observe, competing innovation agendas constitute a significant barrier to the guidance of the search. As shown in Section 4.2.1.2, a perceived difference in industry innovation agendas – borne from the differences in business size and

crop types present in the sector – represents a barrier to a unified, coherent vision for the industry. SMEs do not always have the means to participate in guidance of the search activities, therefore their voice is not heard (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a). As such, this problem is one of *interaction quality*.

3. An area of conflict is evident with respect to long- and short-term vision (see Section 4.2.5). Hermans *et al*. (2015) also mention the trend towards shorter term thinking in policy, leading to incoherent policy decisions and a focus on short-term results. As in New Zealand, research organisations in UK fresh produce, and closely associated levy organisations, were seen to provide 'longer term' thinking (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a). Furthermore, participants from the levy organisations recognised the need for a more 'strategic' approach (see Section 4.2.3). In particular, the call for longer-term vision with respect to crop protection was clear (Section 4.2).

How might these interlinked issues be remedied? Due to the complexity of innovation systems – reflected here in terms of the differences between smaller and larger firms, sectors and their often-competing innovation agendas – "single policy instruments" are not sufficient to guide transformative change. As Lamprinopoulou *et al*. (2012, p. 3) show:

"… a need emerges for developing policy instruments that operate at the system level, instead of supporting the individual components of the system (which may be described as the neoclassical approach), and for going beyond traditional command-and-control measures"

Weber & Rohracher (2012, p. 1043) suggest that the matching of *soft measures*, such as a clearly-articulated vision for the future, with *hard measures* such as a portfolio of policies operating at multiple levels, can overcome the inherent inequalities in power found in an innovation system, where a lack of consensus is common. As such, it is not *only* about the wants of industry but *creating* a vision for all parties that can channel activity. However, in an increasingly internationalised landscape, the notion of limited, national visions stands in contrast to the increasingly globalised nature of the fresh produce industry (and other innovation systems) (Metcalfe, 2007).

Several practical solutions for developing this guiding vision exist (and some, such as Science and Technology Forecasting (STF) have already been mentioned) (see above). Turner *et al*. (2015a) suggest 'consensus development conferences' can provide a means of overcoming the horizontal and vertical fragmentation that exacerbates heterogeneous innovation agendas (Section 4.2.3), in turn improving *interaction*; however, this leaves the question of how to engage those individuals or firms that lack the *capability* to input their voice, unanswered. Mylan *et al*. (2014) point out that, for the dairy sector, periodical "roadmaps" have provided "socio-cognitive coordination", suggesting this might be the intended outcome of any such meeting.

It is not clear whom or what organisations can set out such a coherent, multi-level vision for the industry backed by hard policies. However, commenters have noted the UK's impending (and uncertain) departure from the

European Union – where 80% of the UK's agricultural legislation originates – could be an opportunity to reshape the vision for agriculture (Lawrence, 2017). Nor should the challenges for the industry, highlighted in Section 4.10 be forgotten: for example, the long-term sustainability of the sector – from both an environmental and economic point of view – was considered the key challenge for the future of the industry.

5.2.5 Market Formation

Market formation concerns the creation of new markets, either for new products or existing ones produced in different ways (see Klerkx et al., 2010 for example). Market formation can often be constrained by "incumbent" actors' vested interests (Smink, Hekkert, & Negro, 2013) – making the guiding vision discussed in the previous section all the more important. Developing new markets is, however, vital for an industry that thrives on newness; product differentiation was cited as the foremost 'type' of innovation for the industry (see also Young & Hobbs, 2016), and marketing of those products an equally important component in the innovation journey (Section 4.3.3.4).

It is possible to conclude that market formation activities in the UK are not a particularly weak aspect of the system: aside from complaints about overreach by the levy organisations with respect to market development (Section 4.2.3), and that *more* could be done to promote fruits and vegetables as health foods (Section 4.10), the UK does not suffer from many of those issues outlined by Turner *et al*. (2015a), such as limited instances of actors – including research organisations – undertaking market formation (problems of *presence*). Various organisations, including the levy organisations and crop/sector-specific marketing desks focus on market development, as well as retailers (see below). Government, too, can facilitate market development through policy decisions (see Hekkert et al., 2007, p. 424) though the UK government has adopted an increasingly "hands-off" approach to agriculture (at least in terms of near-market intervention).

However, there several barriers to market formation identified in Chapter 4.

5.2.5.1 Barriers to market formation and mechanisms for change

It is something of a paradox that the main barriers to market formation in the UK fresh produce industry arise from the primary market for most fresh produce – retail markets. As discussed previously, the power of the retailers over the supply chain is considerable (see Section 2.1).

The culture of "defensive innovation", driven in large part by competition between the major retailers, has engendered a risk-averse culture of efficiency improvement that reflects the "conservatism" noted for preventing innovation by Turner *et al*. (2015a). Given the observation that returns to growers have diminished, it can also be speculated that many firms – SMEs in particular – lack the resources to engage in market formation (a problem of *capability*).

At the same time, *information asymmetry* (an *interaction* problem) also clouds market transparency, which is taken to be something that should be avoided (Klerkx et al., 2006; Young & Hobbs, 2016). Exemplified by the reluctance of some firms to share information with their customers Section 4.6.2, Mylan *et al*. (2014) suggest that the development of "antagonistic and distrustful" attitudes towards supermarkets may hinder information exchange. As Metcalfe (Metcalfe, 2007, p. 442) points out:

"… the prevailing constellation of prices, quantities and activities in a market economy generate the opportunities, the incentives and tests that must be passed for innovations to invade and transform the system…"

As such, the withholding of information – for whatever reason – can distort the structures that promote innovation in a market economy.

On the other hand, those relationships founded on trust, exhibiting a "whole supply-chain" view, in which different actors "challenge" each other with need (see Section 4.8.1), appear to represent the best form of working partnership; near-market actors in this instance can focus on market development as part of a package that includes support for those further 'up' the supply chain.

Turner *et al*. (2015a) advocate some kind of bridging or collaboration scheme – with a focus on market development – between retailers and their customers, perhaps in the same vein as the annual meetings organised by certain P.O.s (and, indeed, some retailer-led grower groups like the *Waitrose Agronomy Group* ("The Agronomy Group," n.d.)). Not only would this foster trust but go some way towards combatting *interaction* problems such as *information asymmetry.*

Ensuring adequate returns to growers was cited as a major challenge for the industry (Section 4.10). As such, market formation activities have the ability to provide new or enhanced sources of revenue to growers.

5.2.6 Resource mobilisation

As Hekkert *et al*. (2007, p. 425) point out, resources such as human and financial capital are vital components of an innovation system. Funding for R&D, whether mobilised through industry consortia or public sources, is one measure of this function; whilst it can be difficult to map, Hekkert *et al*. (2007, p. 425) suggest that interviews serve as a means to detect whether core actors perceive access to such resources as problematic.

5.2.6.1 Barriers to resource mobilisation and mechanisms for change

A number of barriers to resource mobilisation were identified in Chapter 4:

1. The size of the horticultural market, which appears to deter significant investment and relegates the fresh produce industry to off-label or "minor" use of crop protection products[19] designed for the arable market (Section 4.6.1.2). Such a situation does not correspond to any of the structural or functional failures outlined by Hekkert *et al*. (2007) or Turner *et al*. (2015a).

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[19] A new facility – the European Minor Use Facility – for off-label use of crop protection products was established in 2015, which recognised the low economic interest of the agro-pesticide industry in "niche" crops (MUCF, 2015).

2. Certain European-wide regulation of crop protection products (and the costs of registration and testing these products in Europe) was also felt to deter investment in agriculture (Section 4.7.1.4) – though one can also argue that this is a driver of innovation as well (Section 4.2.1.1). In particular, the threat to the "minor use" of these products has been noted (Villaverde, Sevilla-Morán, Sandín-España, López-Goti, & Alonso-Prados, 2013). As such, this corresponds to an *institutional* failure related to the *quality* of the regulations that prohibit the use of the products in question or make them prohibitively expensive to register for off-label use. However, attitudes towards regulation, particularly where they concern the environment, should be tempered with concern for unintended consequences of technology: "The necessity to shape innovation processes can be demonstrated by the fact that apart from the advantage of creating economic growth and societal benefits, current use of technologies often has severe negative side effects. Quite often these negative side effects are related to the impact of technology on the natural environment. The relation between technology and the environment is complex and paradoxical. On the one hand, technologies use resources and impose environmental stress. On the other hand, technologies can also lead to a more efficient use of resources, less stress on the environment and even cleaning of the environment." (Hekkert et al., 2007, p. 414).
3. A further problem is the sectoral division of funds that parses out research funding and to some extent prevents more consolidated funding for industry-wide problems (Section 4.7.1.2). This corresponds to an *institutional* failure of *quality* within the levy

organisation funding structure and has some similarities with the situation in New Zealand (Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a).

It is difficult to imagine how one might approach the problems associated with the size of the horticultural market – which is not inconsiderable at some £4 billion at farm-gate (Defra, 2017) and does produce significant innovation. However, the total value of the industry belies the fact that it is made up of many, smaller sectors that, when separated, struggle to attract significant crop protection product development (see Section 4.7.1.3), a situation exacerbated by the high costs of registration for such products in the European Union: "Brexit" may offer an opportunity to change the approval mechanisms for these products, providing an 'advocacy coalition' of concerned parties can be convened (Klerkx et al., 2010; Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a). A mismatch between what was 'taken away' through regulation on crop protection products and investment in alternatives was also an issue aired in Section 4.7.1.4. A possible solution to this problem is the creation of an innovation platform specifically targeting these areas of loss and to also create scenarios for futures with and without certain products (though it should also be noted that research on crop protection measures like IPM continues unabated). Further measures to enhance resource mobilisation in this regard are: 1) the effective *translation* of crop protection methods between crop types, though small market size will continue to be a factor here, and 2) cross-sectoral programs designed to pool resources for the sake of industry-wide problems (as suggested previously and recognised as necessary by senior levy board staff). A reestablished SCEPTRE program (SCEPTREplus) seeks to test the efficacy of crop protection products on horticultural crops on a cross-sector basis (AHDB Horticulture, n.d.), demonstrating the demand for such platforms.

Subsidies, oft-promoted in AIS diagnostic work (see Table 1 in Turner, Klerkx, Rijswijk, Williams, & Barnard, 2015a) as a means to bolster desirable activity, prove rather unpopular in the horticultural sector (possibly due to its entrepreneurial spirit), from smallholders to large-scale businesses and even researchers (Section 4.7.1.4). However, subsidies or tax exemptions do appear to offer a means of facilitating transitions to sustainable futures by providing a niche in which new initiatives can grow free from intense market conditions to challenge the regime (Ingram, 2015).

5.2.7 Creation of legitimacy

Hekkert *et al*. (2007, p. 425) describe the creation of legitimacy as establishing the means of support for new technological trajectories. This can include advocacy coalitions, lobbying for resources, or the establishment of favourable tax regimes, for example. Of course, as noted earlier (Section 2.3.5.3) incumbent actors can treat attempts to disrupt the *status quo* with hostility. Ingram (2015) points out that regimes are less structured for transformative change, and more towards incremental innovation along ‘established trajectories’.

Klerkx *et al.* (2010) call attempts to redefine the hard or soft rules of the innovation system “effective reformism”. Whilst this is not entirely outside the experience of actors in the fresh produce industry (such as persuading others of the importance of longer-term, strategic research (Section 4.2.5)), the notion of legitimacy was primarily invoked not with specific *technology* in mind, but relationships.

Much like Turner *et al*.'s study (2015a), the creation of legitimacy was spoken of rarely during this research, reflecting perhaps a weakness in the functional/structural diagnostic framework. However several barriers to the creation of legitimacy *did* stand out.

5.2.7.1 Barriers to creation of legitimacy and mechanisms for change

As Hermans *et al.* (2015, p. 47) suggest, trust and social capital in agricultural innovation systems in Europe is decreasing: this is problematic for innovation, which relies on trustful relationships and interaction. A lack of trust signals a failure of *interaction quality*. The notion of trust is visited by Sutherland *et al*. (2013) with respect to advisory services, finding that the length of relationships and perceptions of expertise are valued more highly than the affiliation (public, private, or charitable) of the advisor, reinforcing the importance of individual relationships.

That researchers do not always command the respect of growers (Section 4.7.1.2) is likewise problematic for innovation, as this reduces the ability of the scientific community to create the legitimacy needed to further evidence-based agendas (also *interaction quality*). In Section 4.6.1.1 it was stated that, due to trusting relationships between private firms and researchers, businesses would "follow the lead" of particular scientists. Cooperative research programs are therefore advisable, though these are already common in near-market research (such as administered through

AHDB programs and to some extent more industry-focussed BBSRC programmes such as Doctoral Training Partnerships (DTP) which is one of several regional doctoral training programmes that include three-month industrial placements for students (see "Doctoral Training Partnerships (DTP)," n.d.).

However, unlike the situation described by Turner *et al*. (2015a), the onus for the creation of legitimacy appears to lie with the levy organisations: in Section 4.2.5 it was recognised that there was need for longer-term vision and that any reactivity in levy steering groups needed to be challenged.

5.2.8 Summary of functional-structural analysis of the fresh produce industry

In this section, a functional-structural analysis of the fresh produce industry has been undertaken by combining the findings of the previous chapter with existing literature and further developing options for systemic instruments to improve innovative capacity in the industry. These are summarised in Table 11 (below). However, not all the findings discussed in Chapter 4 have found voice through this analysis, and these are explored in more detail in the following section.

Table 11 A functional-structural analysis of the UK fresh produce innovation system with suggested systemic instruments for change

System function	Structural element	Problem "type"	Description	Suggested systemic instrument	Selected examples of systemic instruments identified by this study
Entrepreneurial activities	Interactions	Quality	Knowledge and power asymmetry between customer and supplier	New forms of supply-chain governance	Fresh Produce Adjudicator (see Section 5.2.2)
	Actors	Capability	Some actors have insufficient resources to undertake innovation	Risk capital	
Knowledge development	Institutions	Presence	Fragmentation due to no nation-wide oversight of research activities	Innovation platforms, establishment of coordinating body	UK Agricultural Technologies Strategy (BIS, 2013)

	Interactions	Quality	Reactive steering groups	Demand articulation, widen participation, pooled, cross-sector projects	SCEPTREplus programme (AHDB Horticulture, n.d.)
	Institutions	Capability	Lack of formalised mechanisms for translating research between crop types and through stages of development	Improve incentive structure for translational activity, joined-up policy, strengthen interactions	
	Institutions	Presence	Internationalisation of knowledge development and diffusion has outpaced institutional development	New forms of cross-border partnerships	
Knowledge diffusion	Infrastructure	Presence	Loss of funding and facilities has diminished opportunities for interaction	Focus on intermediary/broker organisations, innovation platforms	Horticulture Innovation Partnership (see Section 5.2.2.1)
	Interactions	Quality	Cognitive gaps limit the quality of interactions	Cooperative research programmes,	Doctoral Training

		between actors; different incentive structures between professions causes a mismatch in goals	intermediary/broker organisations	Partnerships with industrial placements (see “Doctoral Training Partnerships (DTP),” n.d.), HortLINK scheme (see Brian Jamieson & Associates, 2008)
Interactions	Quality	Information asymmetry caused by horizontal fragmentation leaves actors unaware of potential, suitable innovation partners	Intermediary organisations to facilitate networking	
Institutional	Presence	Loss of expertise and specialist knowledge due to inadequate knowledge-	Centralised data-basing	

			handling practices and succession planning	
Guidance of the search	Institutional	Presence	Lack of a national steering mechanism to guide AIS functions	Consensus development conferences, road-mapping
	Interaction	Quality	Some SMEs do not have means to participate in guidance of the search activities, voices not heard	Intermediary organisations
Market formation	Interaction	Quality	Information asymmetry between suppliers and customers with regards to market development	Bridging instruments, collaboration schemes
Resource mobilisation	Institutional	Quality	Regulation blocks use of certain crop protection products and discourages their registration in Europe	Advocacy coalitions /lobbying, innovation platforms for alternative products/scenario development

	Institutional	Quality	Research funding is parsed by sectors, preventing coherent, industry-wide, cross-cutting research	Cross-sector scoping studies, investment in formalised translation mechanisms between crop types	
Creation of legitimacy	Interaction	Quality	Researchers not rewarded for engagement with industry, lack of mutual understanding/trust	Cooperative research programs	Doctoral Training Partnerships (as above)

5.3 Further issues

In addition to those system functions outlined by Hekkert *et al*. (2007) two interconnected issues stand out as important: the idea of best practice in science and extension, and the measurement of the impact of innovation.

5.3.1 Best practice in science and extension

As discussed in Section 4.8.4, the idea of best practice was challenged by the notion of "fit" to specific contexts. This is, on the one hand supported by questions of relevance (see Section 4.8.4) and the common requirement for adaptation (Section 4.5.2).

However, to provide a deeper understanding of the factors at work – and to make sense of other aspects of the data that suggest some innovation is available "off the shelf" – a more thorough discussion of the nature of knowledge is required. Herstad (2014, p. 469) for example, captures the gradients of knowledge succinctly:

"Knowledge can be tacit, hard to observe, complex and system-dependent; that is, it is usable primarily when applied within a given social context… knowledge can also be easy to articulate, observable in use and usable independent of such contexts. These dimensions are important in conditioning the search process underlying partner identification because they determine the sensitivity of search to privileged information access. They also translate into differences in outward communicability and dependence on proximity during interaction, and may necessitate

organizational systems adapted specifically to the task of absorbing the type of knowledge in question."

The situation found 'on the ground' seems to reflect this observation: a pluralistic advisory service composed of private, public and charitable organisations (see Sutherland et al., 2013) engaged in diverse knowledge-exchange practices, including the levy organisations. How and when to impart what types of knowledge is a matter of considerable attention in *extension science* or, as Leeuwis (2004) would like us to term it, *communication for rural innovation* (the totality of which cannot be summarised here). However, several insights have advanced in Chapter 4 with respect to effective forms of communication:

1. *Increasing role of producer organisations as communication nodes for innovation*: as described in Section 4.6.1.2, more formalised producer organisations (such as grower cooperatives) routinely employ their own, in-house agronomists to disseminate knowledge, as well as facilitating interaction amongst their growers through different fora including study tours (see below). Also, strategic partnerships with overseas firms and research institutes provide direct channels for more discreet innovation into the UK. Multiple, overseas production sites also permit more year-round experimentation with new products (such as plant genetics) and processes (Section 4.6.1.1), representing a new area of enquiry for AIS analysis.
2. *Study tours*: either due to, or a response to, the importance of overseas sources of innovation, study tours were consistently cited as important mediums for network formation and knowledge

exchange. These often take place overseas, either with partner organisations or sometimes as bespoke, personal trips (Section 4.5.1). Interestingly, there are very few – if any – published articles examining the role of study tours in fostering innovation in an agricultural context[20], presenting perhaps another area of interest for *extension science* and *innovation systems* inquiry.

3. *Increasing importance of digital and mobile communication*: it is perhaps not surprising to find that digital media and mobile phone communication are now considered primary tools for effective communication (although this hasn't diminished the need for print media, reflecting the need for a multi-channel approach to communication (see Section 4.8.4)).
4. *Confusion with demonstration farms*: it remains unclear as to whether practical demonstrations of new practices and technology provide effective platforms for knowledge exchange. In practice, this may relate to the communicability of the knowledge in question. Context-independent, discreet innovation – in the form of a new pest control product, for example – may correspond to what one participant dubbed "off-the-shelf innovation" (Section 4.2.1.2), more easily transferred through demonstration.

As Driessen *et al*. (2015, pp. 11-12) observe, the innovation systems perspective recognises that innovation is about much more than the "implementation of research results", claiming that instead it must entail "...

[20] Several AHDB publications were featured on the first page of a Google search using the terms "research/study tour agriculture innovation" in July 2017 suggesting it has a prominent role in such events.

acceptance that effective knowledge exchange is essentially about stimulating the formation and function of [] networks”. In conclusion, efforts may be better spent facilitating knowledge flows between and within networks – rather than overseeing the precise implementation of that knowledge – to enhance innovative capacity across the industry. This directly complements more “complexity-aware” theories of change that demand a more advanced understanding of *impact*, discussed below.

5.3.2 Impact

It was stated that determining the impact of innovation was problematic (Section 4.3.4). Indeed, Hermans *et al*. (2015) suggest that there are missing or even unsuitable criteria for evaluation across European AIS in general. This research corroborates that conclusion in some sense: very few concrete means of assessing impact were discovered (at least via the methods of inquiry chosen for the project), representing an area for future research.

The field of impact assessment is large, but in an agricultural context this has tended to focus on adoption of research outcomes as equating to impact, and, in particular, the absolute *number* of beneficiaries of a given product or process. However, Arkesteijn *et al*. (2015) provide a summary of why impact is so problematic an issue with regards to innovation:

“It is uncertain how or whether an intervention leads to a specific result, because of multiple interactions. It is therefore impossible to know beforehand what interventions will work and what the effects of interventions will be. Even if actors have agreed on a solution, and in

hindsight they understand how it worked, a second time the same solution may fail. Acknowledging the inherent unpredictability of any change path taken is assumed to require an integrative, adaptive management style of probing and learning, and a recurrent reflection on emerging patterns."

As Douthwaite & Hoffecker (2017) argue, a linear, cause-effect view of evaluation hampers the ability of research projects to harness such complexity. Instead, they argue that impact is "... achieved through building the capacity of the rural innovation system to innovate..." – of which carrying out research to tackle technical issues is just one component (2017, p. 100).

To deal with the complexities of intervention in innovation systems, which are characterised by uncertainty, ambiguity, risks and unintended consequences, Arkesteijn *et al*. (2015) call for more *reflexive monitoring* of change as proposed by Van Mierlo *et al*. (2010). A recognition that linear, results-based forms of project evaluation do not capture the emergent properties of change has prompted some authors (Van Ongevalle, Huyse, & Van Petegem, 2014) to embrace a *complexity perspective* to adequately take account of emerging barriers to change in a collective manner, in which participants of the projects themselves are able to reflexively guide the direction of change (van Mierlo et al., 2010; Van Ongevalle et al., 2014). A move away from the linear paradigm of problem solving appears to be evident in (at least) Scotland and the Netherlands (see Lamprinopoulou et al., 2012, p. 15).

Some of the systemic instruments proposed to tackle barriers to innovation in the fresh produce industry here will require collective action; no one actor or organisation can solve 'complex problems' (Van Ongevalle et al., 2014), which are, by their nature, problems that persist over time and lack consensus or certainty, but are nonetheless considered problematic (Arkesteijn et al., 2015).

5.4 Rigour, reflections and limitations

It is important at this stage of the Discussion to also assess the rigour with which the study has been undertaken, and in context of the results that have been found.

5.4.1 Ensuring rigour

Rigour is achieved through several means outlined by Mays & Pope (2000) (see below). However, as Roth (2015) notes, scientific rigidity is the first enemy of rigour; indiscriminately applying the same methods of analysis to different contexts is, as such, discouraged. Instead, applying the most appropriate methodology to a given problem is the first step in rigour. The basis for the chosen methodology used in this study is outlined in Chapter 3, alongside justifications for the choices made. Mays & Pope's six ways of ensuring rigour are:

1. *Triangulation*: this refers to comparisons between two or more types of data, or two or more data sources. It is for this reason that this study has sought a diversity of voices across the fresh produce industry, in order to triangulate – via 32 distinct voices – on the issue of innovation. To a lesser extent, secondary document analysis (primarily 'grey' literature related to government policy, such as the

UK Strategy for Agricultural Technologies (2013)) and the use of Basic Horticultural Statistics also provide some degree of triangulation, though in the latter case this represents an area for further development at the methodological level (i.e. mixed-methods research).

2. *Respondent validation*: another method of enhancing rigour is to check the researchers' account (data, notes) with that of the participant themselves. This can help reduce errors, and also be a form of analysis in its own right. However, respondent validation was not carried out in this study, with the exception of two occasions; in one case a participant wanted to see the transcript of their interview (as per the interview protocol) and in another the author sought clarification from a participant regarding on-farm innovation (but did not receive a reply). As such, this may represent a limitation of the research, though as Mays & Pope (2000, p. 51) suggest, a problem that researchers may face in relying on respondent validation is the differing intentions of researcher and participant.
3. *Clear exposition of methods of data collection and analysis*: in order for the reader to be able to judge whether the interpretation proffered by the researcher is supported by the data, attempts should be made to ensure that the process of generating and analysing that data – moving from early, simple systems of classification into more sophisticated coding structures – is clear. In this study, such attempts have been made; an outline of the precise methodology that was followed has been outlined in Chapter 3, and the classification of codes provided at the beginning of Chapter 4. However, it should be acknowledged that more effort could have been made to provide a

breakdown of the evolution of the coding that lead to these classifications.

4. *Reflexivity*: as noted in Section 3.2.1, reflexivity concerns sensitivity to the ways in which the researcher and the research process have shaped the generated data (indeed, this section is part of that endeavour). Mays & Pope (2000, p. 51) also call for the "distance" between researcher and researched to be made clear. With no prior direct experience of either interviewing or the agricultural sector, it is safe to say that this distance was at first large for the present researcher, but gradually diminished. Further reflections on the research process are provided below.
5. *Attention to negative cases*: a "long-established" tactic for improving the quality of data is to discuss those elements in the data that contradict emerging explanations for the phenomena under study (Yin, 2009). Situations in which the data presents an ambiguous picture[21] have been discussed at appropriate points, and the larger themes identified in Chapter 4 represent areas of broad agreement. This is not to say that more attention could not have been paid to contradictory cases or included in the text; however, the inclusion of diverse voices from across the fresh produce industry is in itself an attempt to ensure enough diversity for disagreement, where it exists, to emerge.

[21] As in Section 4.2.1 regarding disagreement over whether the fresh produce industry is one of sharing or protecting important knowledge, and in Section 4.2.2 and Section 5.2.1 in which the positives and negatives of supermarket 'dominance' of the sector are elaborated on.

6. *Fair dealing*: in the same vein, the need for multiple viewpoints should be explicit in the research design of a study, and at the same time, the perspective of one group should not be presented as the "sole" truth of a situation. This has been largely achieved through the recruitment of a large and diverse sample of individuals, both geographically and in terms of their position within the industry. A possible limitation connected to this is the failure to recruit any English potato growers (several were contacted but none replied to the request for interview). As such, only Scottish potato growers were represented in the study, though there were no indications from other interviews with soft fruit growers that there were any major differences – beyond complaints about the weather – between the two nations.

The case study approach also carries with it several methodological considerations, which have been followed during the course of this study. Outlined by Yin (2009), this includes the definition and selection of cases (in this instance, the delineation of the *intrinsic* case of innovation in the fresh produce industry) and a "data collection profile" that yields up-close and in-depth information about the case. The analytic strategy should also be made clear, and this has been outlined in Chapter 3.

5.4.2 Other reflections and limitations

Several other reflections and possible limitations of the research were noted during the course of the project:

- *Framework Analysis*: the extent to which the full analytical power of Framework Analysis was brought to bear on the data was limited, due to the use of the particular CAQDAS supported by University of Warwick. As such, the author was only able to read across cases in a 'manual' way, rather than the systematic way offered by a hand-drawn matrix, presenting a limitation in the application of the chosen data analysis framework. However, it was felt that sound explanatory themes were nonetheless developed.
- *Using the functional-structural analysis*: in contrast, the functional-structural analysis may have provided a restrictive structure to the Discussion (Chapter 5). This was done to give a solid basis to any recommendations made, where systemic tools for change – other than certain programmes and groups – were not pronounced in the Findings (Chapter 4). As such, it was decided to adopt a systematic framework for discussion that could provide a means of 'matching' systemic barriers with those systemic instruments identified elsewhere and by combining these insights with enabling factors and instruments where they had been identified by this study.
- *Internet bias in sampling protocol*: initial identification of possible participants was carried out via the Internet through purposive (Google) searches (see Appendix 1). Although very practical, it has the limitation of filtering out those without an "online" presence. A number of people ultimately took part in the research due to co-nomination sampling, which may have identified individuals that otherwise would have been 'undiscovered', though today this group is likely diminishing.

5.5 Concluding remarks

In this chapter, the findings of the research have been discussed within a functional-structural analysis to pinpoint systemic barriers in the fresh produce industry and match them with appropriate 'systemic instruments' described in existing literature and those outlined as enabling factors in this research. A list of recommendations, based on this analysis, are given in the next section. Several original contributions to the AIS approach have been identified: the internationalisation of the AIS calls for new ways of taking account of cross-border linkages: the importance of producer organisations in fostering such links and acting as innovation nodes also seems to be a new area of enquiry: the apparent 'mismatch' between the promotion of *systemic* instruments for change versus an emphasis (according to this study) on *personal* enabling factors for change.

Finally, the issues of rigour, reflexivity and the potential limitations of the research have been outlined, as well as a brief discussion of how the demands of the case study methodology have been met.

Chapter 6: Conclusions, recommendations, areas for further inquiry

The main aim of this chapter is to outline how this research has met its initial aims, reflect on its original contributions to knowledge and identify areas for future inquiry.

6.1 Responding to the research questions

The questions framing this research were:

1. What are the sources of innovation in the UK fresh produce industry?
2. What are the barriers to innovation in the fresh produce industry?
3. How can innovative capacity be enhanced?

This research has shown that there are multiple sources of innovation in the fresh produce industry, but a perception that innovation often originates overseas – and through direct contact and experimentation with new products or ideas – is evident.

There are also a range of interlinked barriers to innovation, primarily systemic, that limit innovation capacity and that centre on the lack or quality of interactions and institutions. By using a functional-structural analysis of this AIS, it has been possible to match such problems with potential instruments for change to improve innovative capacity in the industry:

1. New forms of supply chain governance can counter the knowledge asymmetry between suppliers and retailers described in Section 4.2. This suggestion is one best handled by either central Government – as in the Groceries Adjudicator – or perhaps by the establishment of a certification scheme that guarantees fair dealing in commercial relationships (in a similar fashion to the Fair Trade Foundation).
2. Establishing a means of providing venture or risk capital to SMEs may improve their ability to innovate (Section 4.2). Innovate UK or a similar organization might be in a position to implement a competitive bidding program for such funds.
3. The fragmentation caused by a lack of nation-wide oversight (and alignment) of research activities can be tempered by appropriate innovation platforms or the creation of a coordinating body (Section 4.7.1). Recent policy developments – such as the Agritech Strategy – provides some orientation for the wider AIS; the existing All-Party Parliamentary Group on Science and Technology in Agriculture (APPGSTA) also provides a means for stakeholder dialogue, but the extent to which that coordinates action across the agri-research sphere is unclear.
4. Fostering better demand articulation, widening participation in steering groups and pinpointing areas for pooled, cross-sector work may help to limit the reactivity of steering groups within the AHDB organisational structure (Section 4.6.2). The AHDB is ultimately responsible for further developing its cross-sector work, and staff within the organisation were aware of the need to do so.

5. Finding ways to incentivise translational research (Section 5.2.2), ensuring that policy is coherent and "joined-up, and providing opportunities to strengthen interaction between actors in the AIS should lay the groundwork for more reliable translation of research. A number of organisations can facilitate these aims, such as AHDB (see above) and BBSRC, through prioritization of cross-sector and translational work. However, more basic, blue-skies research should remain 'ring-fenced', as it is here that the breakthroughs of tomorrow might occur (see Menary, 2015).
6. The internationalisation of knowledge development described in Section 5.2.1 calls for new forms of cross-border partnership (what one might call "institutional innovation"). Such partnerships can be formed at a number of 'levels' and are not uncommon between universities and academic societies. However, the AHDB's already prominent role in study tours and familiarity with producer organisations suggests that it could be a key node in such activities.
7. The loss of funding and dedicated facilities in the sector (Section 4.7.1.2) requires the establishment of, or support for, other mechanisms to foster interaction, such as intermediary organisations or innovation platforms. Central Government and the UK Research Councils have a clear role here – and have provided funding for dedicated facilities in the last few years.
8. Given that cognitive gaps between industry actors and different incentive structures cause barriers to the useful exchange of knowledge (Section 5.2.3) cooperative research programmes or intermediary organisations can provide platforms for more productive interaction. Different institutions – from the AHDB to

multi-university training partnerships – can facilitate the creation of these platforms.

9. Where information asymmetry prevents actors finding suitable partners (Sections 5.2.1 and 5.2.4) intermediaries might offer a means to match appropriate individuals or organisations.
10. The loss of expertise and specialist knowledge described in Section 5.2.3.1, calls for the creation of centralised data-basing. This presents a significant challenge for any organisation seeking the consolidation of knowledge – the AHDB being the most likely candidate considering its position within the AIS.
11. The lack of national steering mechanisms to guide AIS functions (Section 5.2.2) requires the development of 'roadmaps' or other guiding plans through consensus-building conferences. The responsibility for this most likely lays with central Government, which has already taken a lead in developing certain roadmaps for UK agriculture.
12. Intermediary organisations can act as a conduit for those SMEs whose voice is not heard in 'guidance of the search' matters (Section 5.2.3).
13. Bridging instruments and collaboration schemes can counteract the information asymmetry between suppliers and customers with regards to market development (Section 5.2.5). Here, UK retailers are best positioned to 'lead' their supply chains in fostering the mutually-beneficial sharing of information (the extent to which this is already done appears to vary between sectors Mylan et al., 2014).
14. Where regulation is seen to block the use of or innovation in pest control products, advocacy/lobbying groups are required to change

policy (Section 5.2.6.1) – alternatively, innovation/technology platforms and scenario development might also offer a means to generate substitute products. The AHDB's SCEPTREPlus programme is a viable vehicle for ensuring that vital pest control products are not lost – or that their withdrawal is gradual rather than sudden.

15. Issues associated with the division of research funding by crop type (Section 4.7.1.2) might be alleviated by cross-sector scoping projects to find areas of common concern, and investment in formal translational mechanisms. The AHDB – and to some extent BBSRC – has a central role to play in this respect, though as noted earlier this has largely been recognised and new programs now exist to find cross-cutting themes in agricultural problems (see AHDB Horticulture, n.d.).
16. If researchers are not rewarded for engagement with industry, which exacerbates a mutual lack of understanding between them and other actors, then cooperative research programs may provide a forum for improving interaction (Section 5.2.3.1).

6.2 Original contributions to knowledge and areas for further inquiry

In addition to the recommendations made here, and being the first study of its kind to focus on the fresh produce industry, this project has also made several original contributions to knowledge, particularly with respect to diagnostic AIS research:

1. *Global Innovation Systems*: the increasingly globalised nature of the innovation system, in which firms establish overseas production

sites or form strategic alliances with foreign businesses appears to be an understudied – yet important – feature of the modern fresh produce industry.

2. *Producer organisations as innovation nodes*: producer organisations appear to be vital networks for affiliated growers, acting as conduits for innovation through increasingly formalised networks with in-house agronomists and frequent events, including study tours (see below). By partnering with overseas businesses, P.O.s also spread proprietorial knowledge and products that would otherwise be restricted – and in so doing, further the globalisation of the innovation system. However, it was acknowledged that being inside such networks might restrict other, "outside" knowledge from having impact (closed networks).
    a. *Study tours*: relatively little dedicated research has been undertaken to investigate study tours as a tool for agricultural knowledge exchange. Given that this research has indicated the importance of overseas sources of innovation, and that study tours routinely involve overseas travel, such tours represent an area in need of further scrutiny.
    b. *Intermediaries:* as described in Section 5.2.3 (*Knowledge diffusion*), intermediary organisations in the UK are less developed than, or at least different to, their counterparts elsewhere. Any intermediary functions undertaken by producer organisations therefore require further inquiry, because it is clear that certain intermediary duties are carried out within such organisations (see Section 4.6.1.2).

3. *Possible mismatch between systemic barriers and personal enabling factors for change*: diagnostic AIS works places strong emphasis on the systemic factors affecting innovation. However, this study has determined that whilst the barriers to innovation are overwhelmingly systemic in nature, enabling factors for change tend to lie with the individual; entrepreneurialism, trust and leadership, for instance, were deemed vital to the innovation process. This suggests that there may be scope for further theoretical development in the AIS approach, but also perhaps reinforces the divide in focus between AIS and higher-resolution approaches to innovation such as FSR. Other weaknesses of the approach are presented by Schut *etl al*. (2014b) in Table 3 (Chapter 3) as being the complexity of delineating the AIS, and the lack of empirical evidence of practical impact and value. The former, the present researcher would argue, actually belies a strength of the approach; identifying the limits of a system of concern, in order to properly capture the diverse voices within it, is justified in that it can provide a self-correcting mechanism for other problems identified in the wider literature (such as progressive farmer bias (Section 5.2.3.2)). In turn, and particularly when paired with the matrices found in the Framework approach outlined by Ritchie & Spencer (2003), cross-cutting themes important to a whole sector can be identified (as done here). The latter, however, may represent a critical failure of the approach, particularly as the discipline itself emphasises the diagnosis and remediation of problems. A third weakness, as identified here, lies in connecting the personal, lived experience of innovation to higher-level themes. Equally, the AIS approach – by itself – does not address notions of

power, identified in other literatures, such as rural sociology, as being a prime explanatory factor determining agricultural outcomes (see Goverde, Haan, & Baylina, 2004; Kovách, 2017 for instance). With these observations in mind, it is possible to recommend AIS as a conceptual framework where research questions concern higher-level systemic issues – such as those concerning research councils, levy organisations and universities. Likewise, applied qualitative approaches such as interviewing seem to be adequate means of informing AIS diagnostic work. However, in its present form – or, it should be noted, in its application in this study – AIS appears ill-equipped to make use of all forms of data that arise in discussions of innovation. That being said, Klerkx *et al.* (2010) *do* strike a balance between high-resolution case studies (framed as 'innovation journeys') and the attempts by innovating actors to alter their local institutional environment. As such, the AIS approach has most value when bridging the personal and the systemic via discrete innovation(s) or innovation projects to enhance its practical, empirical impact (rather than more expansive, essentially *post-hoc* appraisal of an entire sector).

In summary, this thesis has met its initial aims of discerning the sources of innovation in the UK fresh produce industry, as well as what acts as a barrier to innovation. In turn, it has developed a series of recommendations as to what can enhance innovative capacity in the industry. In so doing, it has also identified areas for future study and novel contributions to knowledge, as well as assessing the suitability of the AIS approach to answer key questions about agricultural innovation.

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Glossary

Adaptation	Modification of a product or process to suit (some other) requirement
Adoption	The take-up of new knowledge or product by a given unit
Agent/agency	The individual, and their ability to affect a given situation or environment
Applied research	Science undertaken with a practical application in mind
Best practice	Optimal use of resources or methods of production as determined by specific research
Bounded rationality	The assumption that when agents make decisions they are limited in terms of knowledge and time (often contrasted with *perfect rationality*)
Brokerage	The mediation of different interests to develop appropriate solutions to a problem
Capital (financial, social or human) (economics)	Anything that can increase an individual's power to perform economically-useful work

Cases (Framework Analysis)	Units of analysis in Framework Analysis (often individual research participants)
Codes	A discrete label with which to describe meaningful information in qualitative analysis (usually the starting point in such analyses)
Collective innovation	The process of developing solutions to a given problem in an interactive, collaborative way
Discounters	Supermarkets specialising in low-cost, "discount" products
Effective reformism	The process by which agents alter an institutional landscape to better suit their needs
Evolutionary economics	An approach to economics, which concerns the processes that shape an economy for firms, institutions and other actors within that economy
Extension/advisory services	State-sponsored organisations offering agronomic advice to the farming community
External validity	The extent to which research findings can be extrapolated to wider circumstances

Feedback (systems theories)	The outputs of a system become inputs that form a cause-and-effect chain or loop
First/early adopters	Those quickest to begin using a certain process or product from a given population (see *laggards*)
Governance	The process of decision-making in a given area
HortLINK (schemes)	A four year joint Defra-funded program created to address “gaps” in crop protection
Impact	Outcomes of using a certain product or process
Implementation	Putting new knowledge or products into functional use
Incremental (innovation)	Slow, small changes in the way a process or product works (often compared to “revolutionary” innovation)
Indexing	The process of sorting codes into higher order themes
Information/knowledge asymmetry	The unequal distribution of information or knowledge (often between suppliers and customers)
Innovation platforms	A means to bring together different stakeholders to solve a particular

	problem or promote a certain solution
Institutions	Stable, recurring patterns of behaviour that confer structure on social systems
Internal validity	The extent to which a conclusion can be said to be drawn from the evidence presented in a study. Enhance by rigour, and often contrasted with *external validity*
Knowledge infrastructure	The physical components of a *knowledge system*, such as the research facilities and communications services in a certain locality
Knowledge markets	The market for a certain type of information, used in agriculture to describe the demand and supply of agricultural knowledge
Knowledge systems (systems theories)	The process of producing, using and storing knowledge in a given locality or industrial sector
Laggards	Those who are slowest to begin using a certain product or process from a given population (see *first/early adopters*)

Learning process (innovation systems)	The ways in which new knowledge, which enables innovation, is acquired
Levy board	Agriculture and Horticulture Development Board (AHDB), UK-wide organisation funded by statutory levy from commercial farming operations
Linear Model (of innovation)	A model of innovation that depicts research as the origin of innovation, followed by development, marketing and sale of a specific product (often challenged in systems approaches to innovation)
Marketing desk	A means of consolidating supply of a horticultural good, which also perform marketing functions
Multiple retailers	Supermarkets with multiple retail sites
Near-market	Industrial/scientific research concerned with a product or process that is nearing a marketable stage (see *applied research*)

Neoclassical (economics)	An approach to economics concerned with output, prices and distribution in markets as determined by supply and demand
Norms (society)	Informal understandings that govern behaviour in social systems
Oligopsony	A market arrangement in which there are few buyers of goods
Perfect rationality (economics)	The assumption that 1) agents will always act to maximise their utility (personal benefit) and 2) do so in an informed manner (often compared to *bounded rationality*)
Points of difference	Product differentiation
Policy coordination failure	A situation in which there is a lack of policy coordinating mechanisms, or where these function poorly/are contradictory
Productivity (economics)	A measure of the efficiency of producing a given product(s)
Reflexive monitoring	A method that promotes constant learning within multi-actor groups to cope with complex change
Regime	The established or “normal” mode of production or social arrangement

Revolutionary (innovation)	Step change innovation that redefines or replaces previous systems
Structure (social sciences)	Patterned arrangements in society that come from and determine the actions of individuals
Systemic instrument	Policy mechanism to solve a systemic barrier to innovation
Technological trajectories	A ‘branch’ in the evolving design of a particular product or process
Technology “push”	Research and development of new products drives their uptake (often contrasted with technology “pull”, whereby demand for a certain product drives research and development)
Thematic analysis	A form of qualitative analysis that focusses on discovering patterns in data that relate to specific research questions

Appendices

Appendix 1: Literature review

A literature review was carried out in Spring 2014 using some of the terms associated with the initial research questions framing the project. These were:

1. What are the sources of innovation in the fresh produce industry?
2. How is the fresh produce research and development/knowledge transfer pipeline constructed?
3. What are the issues or problems relating to translation and exploitation of research within the supply chain?
4. Are these problems specific to a particular part of the supply chain?
5. What methods of knowledge transfer/communication channels have been found to be the most effective?
6. Are there good examples of effective translation and exploitation of research?
7. What possible metrics of exist to measure the degree of success in translation of research into use?
8. How to stakeholders go about communicating their needs to other parts of the supply chain?
9. What incentives exist/should exist for producers to take up new technologies or methods?
10. What possible actions or recommendations would help address the issues?

These research questions were derived from a report on the concept of "research into use" (National Horticultural Forum, 2011b), which examined the utilisation of research within two distinct sectors (strawberry and brassica production). The search terms used with respect to these questions are highlighted in Table 12, and feature an emphasis on general innovation, *translation* and *implementation* as the core concepts[22]:

Table 12 Key search terms and databases consulted during initial literature review

Topic	Search term	Database
Innovation (general)	Innovation (in) agriculture	*Google Scholar*
	Agricultural research pipeline	*Google Scholar*
	Agricultural research + translation	*ScienceDirect*
	Innovation + horticulture	*Google + Google Scholar*
	Sources (of) innovation	*Google + Google Scholar + ScienceDirect*
Economics	Innovation + economic theory	*JSTOR + Google Scholar*
	Technological change	*JSTOR + Google Scholar*
	Evolutionary economics	*Google Scholar + ScienceDirect*
Translation	Translation (of) basis science	*Google Scholar*
	Technology transfer	*ScienceDirect*
	Research translation	*ScienceDirect*

[22] These terms were also used in conjunction with a conference paper (*Agricultural Innovation: Lessons from Medicine*) written by the author for the Innovation Through Knowledge Transfer 2015 conference.

	Translational science + agriculture	*Google Scholar*
Implementation	Implementation science	*Google Scholar*
	Implementation (of) agricultural innovation	*Google Scholar*
	Extension science	*ScienceDirect*
	Innovation diffusion	*Google Scholar + ScienceDirect*

However, it became clear that these questions were, on the one hand, reflective of the 'linear model' of innovation, which, as described in Section 2.3.5.2, has been repeatedly challenged in recent years (particularly where agricultural innovation is concerned) and, on the other, presumptive of the kinds of problems affecting the fresh produce industry. As such the, research questions guiding the project were developed in conjunction with the literature that most closely relates to innovation in an agricultural context (i.e. Agricultural Innovation Systems). An iteration of the literature review took place that emphasised innovation systems terminology:

Table 13 Improved search terms and databases consulted during literature review

Topic	**Search term**	**Database**
Innovation Systems/AIS	Agricultural systems analysis	Google Scholar + ScienceDirect
	Agricultural knowledge systems	Google Scholar
	Barriers to innovation + agriculture	Google Scholar + ScienceDirect
	Facilitating innovation + agriculture	Google Scholar + ScienceDirect

Appendix 2: Note on Defra's June Survey of Agriculture and Horticulture

In 2010 Defra changed certain labour thresholds to be more in-line with European standards, resulting in less recorded commercial holdings and thus excluding the least active farms (Defra, 2012). It also reduced an upward trend in the number of small-holdings being registered with the organisation, perhaps accounting for both the sudden rise and fall of farms in the 2005/2006 bracket.

Appendix 3: Ethical principles and relevant forms

Four ethical principles have been developed to ensure that any research involving human subjects is carried out in an ethical manner (see Gillon, 1994). These are:

1. Autonomy: there is an obligation to respect the autonomy of individuals by being honest in one's dealings with others and keeping promises made to them
2. Beneficence: this refers to the obligation to provide net benefit to others, or at least to do 'no harm' to them (non-maleficence)
3. Non-maleficence: the obligation to avoid doing something that might harm others
4. Justice: this is the obligation to be fair in dealings with others.

Further to this, and in keeping with the University of Warwick's own ethical guidelines, an interview protocol was developed, in conjunction with a participant information and consent form, to ensure that the project proceeded in an ethical fashion (see interview information pack and consent form below).

THE UNIVERSITY OF WARWICK

Study Title: **Sources of Innovation in the Fresh Produce Industry**

Investigator(s): **Jonathan Menary**

Introduction

You are invited to take part in a research study. Before you decide, you need to understand why the research is being done and what it would involve for you. Please take the time to read the following information carefully. Talk to others about the study if you wish.

(Part 1 tells you the purpose of the study and what will happen to you if you take part. Part 2 gives you more detailed information about the conduct of the study)

Please ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

PART 1

What is the study about?

The aim of the study is to identify sources of innovation in the UK fresh produce industry and what barriers exist to its development, spread and uptake. It is hoped that this research will contribute to better policy.

Do I have to take part?

It is entirely up to you to decide. We will describe the study and go through this information sheet, which we will give you to keep. If you choose to participate, we will ask you to sign a consent form to confirm that you have agreed to take part (if part of this study is an online or postal questionnaire/survey, by returning a completed questionnaire/survey, you are giving your consent for the information that you have supplied to be used in this study and formal signed consent will not be collected where postal or online questionnaires/surveys are concerned). You will be free to withdraw at any time, without giving a reason and this will not affect you or your circumstances in any way.

What will happen to me if I take part?

If you decide to take part in this study, you will be asked several questions about innovation in the horticultural industry via a semi-structured interview. Interviews will typically last one hour.

What are the possible disadvantages, side effects, risks, and/or discomforts of taking part in this study?

This study will only capture your opinions about innovation in the horticultural industry, and as such there are very few risks; however, if you feel that your opinion may be controversial, you can opt for anonymity.

What are the possible benefits of taking part in this study?

There are a number of benefits of this study:

- The study may contribute to new and better horticultural policy in the future
- The research will provide a modern examination of the horticultural industry and how horticultural research is conducted
- It is the first time a study like this has been done in this field, and as such you could be contributing to a novel area of horticultural research

Expenses and payments

There should be no expenses incurred as a result of taking part in this research.

What will happen when the study ends?

At the end of the study, the data collected will be analysed and included in the author's thesis; it may also be published in relevant journals.

Will my taking part be kept confidential?

If you would like your opinions to be kept confidential, we will follow strict ethical and legal practice; all information about you will be handled in confidence. Further details are included in Part 2. If you do not wish to remain anonymous, then your name and affiliations may be included in a thesis and/or academic journals, subject to acceptance.

What if there is a problem?

Any complaint about the way you have been dealt with during the study or any possible harm that you might suffer will be addressed. Detailed information is given in Part 2.
"

This concludes Part 1.

If the information in Part 1 has interested you and you are considering participation, please read the additional information in Part 2 before making any decision.

PART 2

Who is organising and funding the study?

The study is organised by Jonathan Menary, a PhD student at Warwick Crop Centre, under the supervision of Dr Rosemary Collier, head of the Warwick Crop Centre. The project is funded by the University of Warwick, the Horticultural Development Company (HDC) and the UK Potato Council.

What will happen if I don't want to carry on being part of the study?

Participation in this study is entirely voluntary. Refusal to participate will not affect you in any way. If you decide to take part in the study, you will need to sign a consent form, which states that you have given your consent to participate.

If you agree to participate, you may nevertheless withdraw from the study at any time without affecting you in any way.

You have the right to withdraw from the study completely and decline any further contact by study staff after you withdraw.

!

What if there is a problem?

The University of Warwick's insurance and indemnity cover covers this study. If you have an issue, please contact Jo Horsburgh (details below).

Will my taking part be kept confidential?

Due to the nature of the interviews, the interviewer will necessarily know the identity of the interviewee. However, if a request for anonymity is made, steps will be taken to ensure the confidentiality of the interviewee's opinions; handwritten notes, if any are used, will be digitised and the originals will be destroyed; data related to the project will be kept on a password protected computer (owned by the University) that can only be accessed by the interviewer and IT support staff; any anonymous data will be deleted at the end of the project.

What will happen to the results of the study?

The results of the study will be analysed and potentially included in a doctoral thesis; they may also be included in papers published in academic journals, subject to acceptance. If you would like a copy of the thesis, or any future papers associated with the project, please email the author at the email address below.

Who has reviewed the study?

This study has been reviewed and given favourable opinion by the University of Warwick's Biomedical and Scientific Research Ethics Committee (BSREC): REGO-2014-1041 (August, 2014).

What if I want more information about the study?

If you have any questions about any aspect of the study or your participation in it not answered by this participant information leaflet, please contact:

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+447725754514

or

Dr Rosemary Collier
rosemary.collier@warwick.ac.uk
024 7657 5066

Who should I contact if I wish to make a complaint?

Any complaint about the way you have been dealt with during the study or any possible harm you might have suffered will be addressed. Please address your complaint to the person below, who is a Senior University of Warwick official entirely independent of this study:

Jo Horsburgh
Deputy Registrar
Deputy Registrar's Office
University of Warwick
Coventry, UK, CV4 8UW.
T: +00 44 (0) 2476 522 713 E: J.Horsburgh@warwick.ac.uk

Thank you for taking the time to read this participant information leaflet."

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Consent Form

1. I wish to remain anonymous ☐

2. I agree that my interview will be recorded and that anonymized quotations may be included in any future publications or presentations related to this research ☐

3. I understand that I can request a copy of my interview transcript (to amend or otherwise change information therein) ☐

Name: Date: Signature: