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AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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GROWER SUMMARY

Headline

A range of mechanisms are proposed to bring down barriers to innovation in the fresh produce industry.

Background

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, 2011). Innovation, technological and non-technological change, has been promoted to help meet these challenges. However, there are barriers to innovation across the fresh produce value chain that slow or prevent new knowledge and innovations from making impact.

Summary

This project aims to identify the sources of innovation in the UK fresh produce industry, determine which factors contribute or impede successful innovation and identify how we might build innovative capacity in the industry. To do this, 35 industry experts were recruited from across the industry to take part in interviews. At the close of the project, a number of evidence-based recommendations have been made to help to remove these barriers to innovation.

Methods

Initially, an extensive literature review was undertaken to scope the wide range of topics relevant to the project. In addition to consulting published literature, horticultural data was compiled using Defra's Horticultural Statistics publications from 1945/6 to 2011, taking account of area under cultivation, gross output and subsequent productivity.

Following the initial literature review, a further review was conducted examining the comparability of agricultural research and medical research, with specific focus on translational research and implementation. The conclusions of this work were presented at the *Innovation Through Knowledge Transfer* conference in Staffordshire in 2015.

The first stage of primary data collection involved a series of semi-structured interviews with industry experts. Interviewees were selected based on purposive sampling and co-nomination sampling (asking interviewees who else should be interviewed in their opinion,

also called 'snowballing'). In general, the interviews were conducted at the interviewee's place of work, though several were conducted at Warwick Crop Centre.

The interviews were recorded via Dictaphone, transcribed and 'coded' through *Framework Analysis*, a qualitative research methodology increasingly used in medical and health research. Computer Assisted Qualitative Data Analysis Software (CAQDAS) *Nvivo* was used to organise the data for analysis. Questions concerned five topics, each with a set of sub questions:

1. *Innovation in the FPI*
2. *Barriers and Facilitation of innovation in the FPI*
3. *Contribution to innovation in the FPI*
4. *Representation in the FPI*
5. *Challenges for the FPI*

Interviews were carried out across England, Wales and Scotland. A range of voices was heard from most sectors of the fresh produce industry, including ornamentals, potatoes and protected edibles.

Findings

A number of themes emerged relating to different aspects of the workings of the industry, which can be organised as follows:

1. *Norms & institutions*
2. *Innovation in fresh produce*
3. *Drivers of change*
4. *Sources of innovation*
5. *Communication in the industry*
6. *Industry bottlenecks*
7. *Enabling factors*
8. *Comparisons with the past*
9. *Challenges*

These are explained in more detail below:

1. Norms & Intuitions

Many observations were made by interviewees concerning the *nature* of the fresh produce industry and the actors within it: it was not always made explicit how these observations affect innovation, but it is clear that the nature of the industry determines its institutional landscape, innovation needs and outcomes. A strong vein of entrepreneurialism appears to define the industry, and so new ideas are given a high priority amongst businesses that can mobilise knowledge effectively. However, the power and influence of retailers was also noted and the relationships between supplier and customer can vary substantially across the industry.

2. Innovation in fresh produce

A number of observations were made with regards to how those who engage with innovation define and measure it. This theme also explored more general observations about innovation processes, including the notion of unpredictability.

3. Drivers of change

The drivers of change in the industry, here defined as phenomena that encourage or force actors to innovate, were, perhaps predictably, strongly economic; many interviewees cited 'necessity' or 'need' as factors prompting innovation, due to the rigours of an intensely competitive marketplace both at the production and retail ends of the supply chain. *Regulation* was also seen as a driver of innovation, although this was often an area of considerable disagreement.

4. Sources of innovation

While it is not possible to *rank* the contribution of different actors to innovation in the fresh produce industry, we can begin to examine the role of different organisations and sectors in pushing the industry forward, and also how the approach to research and development is changing. An 'internationalisation' of innovation appears to be underway, with organisations actively collaborating in multi-stakeholder 'innovation networks' operating in globalised contexts, helping such organisations meet the needs of their 'innovation agendas'.

5. Communication in the industry

How actors go about communicating with one another is important, and this theme 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.

6. Industry bottlenecks

This theme 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 unfavourable regulatory environment and “defensive” innovation culture. In contrast, personal barriers to innovation hinge on risk, uncertainty and the fear of failure.

7. Enabling factors

This theme 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 is paramount, and understanding its context. Likewise, extension practices are context-dependent, requiring different approaches not only for different people but also for different “types” of innovation.

8. Comparisons with the past

The ways in which present circumstances are contrasted with, and linked to, decisions made in the past, was a common topic of discussion. 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.

9. Challenges

Finally, this theme investigated the challenges faced by the industry today, focussing on the idea of sustainability, both economic and environmental. Ensuring that new pest control products or practices remain 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.

Discussion

By comparing the situation in the UK with that of other countries' 'innovation systems', such as New Zealand and the Netherlands, several 'systemic' instruments are recommended for *solving particular problems, including:*

- New forms of supply chain governance to prevent uneven levels of knowledge and power between customers and suppliers
- Pooled, cross-sector projects and improved dialogue to take account of long-term, common-to-all problems
- Cooperative research programmes to ensure dialogue between people of different professions
- Modified incentive structure to promote translational science between fresh produce sectors and basic & applied research
- Advocacy groups to ensure favourable policy regime for crop protection products moving forward

Financial Benefits

The value of improving the innovative capacity of UK fresh produce stands to be large, but remains difficult to quantify.

SCIENCE SECTION

Introduction

The UK fresh produce industry faces a number of challenges. 'Innovation' has been promoted to help meet these challenges. However, the ways in which innovation in the industry is constrained – if at all – have not been explored.

Over the last decades, the previously dominant agricultural research and development (R&D) regime has evolved along increasingly demand-driven lines, challenging the 'post-War' model of *research-extension-farmer* and creating new problems and opportunities for innovation in farming systems.

At the same time, UK agricultural productivity is also lower than that of many of its competitors. 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, 2008, p. 261).

In light of these interconnected issues, the Agriculture and Horticulture Development Board and the University of Warwick proposed a project to explore these issues. This was undertaken as a PhD project by Jonathan Menary and was funded by AHDB Horticulture (25%), AHDB Potatoes (25%) and the University of Warwick (50%).

Following the literature review, the initial research questions were modified to reflect the pertinent questions of *Agricultural Innovation Systems* (AIS) enquiries, being:

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?*

The precise approach taken to answer these questions is discussed below.

Materials and Methods

Initially, an extensive literature review was undertaken to scope the wide range of topics relevant to the project. In addition to consulting published literature, horticultural data was compiled using Defra's (previously MAFF's) Horticultural Statistics publications from 1945/6 to 2011, taking account of area under cultivation, gross output and subsequent productivity.

Following the initial literature review, a further review was conducted examining the comparability of agricultural research and medical research, with specific focus on translational research and implementation. The full paper, which was presented at the *Innovation Through Knowledge Transfer* conference in Staffordshire in 2015, is available online (see *Knowledge & Technology Transfer*, below).

The primary data collection involved a series of semi-structured interviews with industry experts. In the first instance, ethical approval to conduct the interviews was obtained from the University of Warwick *Biomedical and Scientific Research Ethics Sub-Committee* (REGO-2014-1041). A project information pack was also developed to send to potential interviewees electronically, providing information about the study, how the data they might provide would be used, enabling them to make an informed choice about whether or not to take part in the research. Interviewees were selected based on purposive sampling and co-nomination sampling (asking interviewees who else should be interviewed in their opinion, also called ‘snowballing’). In general, the interviews were conducted at the interviewee’s place of work, though several were conducted at Warwick Crop Centre. The data generation period of the research ran from May 2015 – January 2017. About 70 people or organisations were approached for interview,

The interviews were recorded via Dictaphone, transcribed and ‘coded’ through *Framework Analysis*, a qualitative research methodology increasingly used in medical and health research (Gale, Heath, Cameron, Rashid, & Redwood, 2013). While there are a number of applied analytical frameworks for dealing with qualitative data, *Framework Analysis* was chosen because it is not aligned to a particular epistemological, theoretical or philosophical approach; it allows for a combination of *deductive* and *inductive* reasoning, which in turn permits the researcher to code in an ‘open’ manner whilst being aware of the assumptions of existing, related literature; it provides clear steps to follow to summarise data in a highly structured way, the output of which is a matrix of organised data that is easy to assess further by case (interviewee) and code (phenomena). Those steps for each case consist of:

1. *Transcribing the interview recording*
2. *Familiarisation with the interview* – the researcher should go over any notes made during the interview and listen to the recording to ensure that they are familiar with it
3. *Coding* – the researcher reads the entire transcript, applying a label to ‘important’ information (a code) that in more inductive studies – and in the initial stages of coding for

this project – is done ‘openly’, i.e. taking into account anything that might be considered important from a range of perspectives.

4. *Develop an analytical framework* – these early transcripts provide the codes, grouped into categories that form the basis of the analytical framework for subsequent coding to build upon.
5. *Applying the analytical framework* – the framework is then used to index remaining transcripts.
6. *Charting data into the framework matrix* – the charting process involves summarising the data by category from each transcript in a spreadsheet-like matrix, striking a balance between reducing the data and retaining its original meaning.
7. *Interpreting the data* – at this stage, the characteristics of and differences between the data are investigated, with possibilities for generating typologies, interrogating theoretical concepts and – if the data are rich enough – going beyond description and explaining “... reasons for the emergence of a phenomenon, predicting how an organisation or other social actor is likely to instigate or respond to a situation, or identifying areas that are not functioning well within an organisation or system” (Gale et al., 2013).

Computer Assisted Qualitative Data Analysis Software (CAQDAS) *Nvivo* was used to organise the data for analysis. Questions concerned five topics, each with a set of sub questions:

- *Innovation in the Fresh Produce Industry*
- *Barriers and Facilitation of innovation in the Fresh Produce Industry*
- *Contribution to innovation in the Fresh Produce Industry*
- *Representation in the Fresh Produce Industry*
- *Challenges for the Fresh Produce Industry*

By choosing a semi-structured approach, the interviewer is able to probe points made by the interviewee and pursue any lines of questioning felt to be relevant, without losing sight of the central theme.

Results

In total, 35 interviews were undertaken (representing a 50% response rate); 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, three with experts in agricultural knowledge/innovation systems research, and two with a specific technology in mind (polytunnels). Table 1 provides a breakdown of the various roles of those interviewed.

Table 1. Breakdown of current role of participants (excluding 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 Scotland and Wales) most commonly at the participants' place of work or at Warwick Crop Centre where the researcher is 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.

Using Framework 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 transcripts were then analysed in accordance with *Framework Analysis*, which produced 9 'higher-level' categories with numerous sub-themes (Table 2).

Table 2. List of top-level categories and sub-themes developed during data analysis.

Top-level categories	Sub-themes
Norms & institutions	<ul style="list-style-type: none"> • Specificity & difference within the fresh produce industry • 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	<ul style="list-style-type: none"> • Defining innovation • Observations about innovation processes • Types of innovation • Impact & measurement of innovation
Drivers of change	<ul style="list-style-type: none"> • Economic drivers • Retail needs • Regulation
Sources of innovation	<ul style="list-style-type: none"> • Overseas sources of innovation • Learning by doing • Individual businesses and organisations • Formal research
Communication in the fresh produce industry	<ul style="list-style-type: none"> • Positive interfaces and successful brokerage <ul style="list-style-type: none"> ○ Networks ○ The role of different organisations and actors ○ Specific projects • Barriers to effective communication and collaboration
Industry bottlenecks	<ul style="list-style-type: none"> • Systemic barriers <ul style="list-style-type: none"> ○ Fragmentation ○ Formalised research ○ Economic factors ○ Regulatory constraints ○ Culture • Personal barriers
Enabling factors	<ul style="list-style-type: none"> • Systemic enabling factors

	<ul style="list-style-type: none"> • Personal enabling factors <ul style="list-style-type: none"> ○ Interactivity ○ Human & 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 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”).

The remaining part of this section will outline these findings. The number of the interviewee follows any quotation from that participant, and the themes are also numbered for convenience.

1.1 Norms & institutions

A category emerged from the data relating to what might be called 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 dubbed “norms & institutions” and can be 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.

1.1.1 Specificity & 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 and the observations made provide context for subsequent sections; “Scale and size of farm businesses”, 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 market place. (8)

At the same time, horticulture is considered a more marginalized sector – compared to, say, arable farming – and had “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. 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 these networks form the basis for a good deal of the innovation taking place in today’s fresh produce industry.

1.1.1.1 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. 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 has increasingly 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, 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 conducted 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, of course the AHDB remains responsible for many of the functions previously undertaken by public research and extension services, and this is discussed in greater detail later on.

Interestingly, the 2007/08 Financial Crisis and subsequent Recession 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 Four". 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. Of course, 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 and buying it and then repeat purchasing it, so I think we're also seeing as a 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 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.

1.1.1.2 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, levy organisations and 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.

1.1.1.4 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 an AIS scholar at Wageningen 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).

1.1.2 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 to 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 organized 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*
- *restrict 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 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 (perhaps a result of successful innovation?):

... [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.

However, multiple retailers are not the only actors influencing the industry. Government and other organisations – or “politics” – 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)

Of course, 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 this research project.

1.1.3 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 this 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 3. 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 – not 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 look 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 3 constitute barriers to innovation in their own right, and combine with other factors to impede innovation.

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.

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 AHDB, 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.

1.1.4 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 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.

1.2 Innovation in Fresh Produce

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

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

These themes are explored in more detail below.

1.2.1 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.

1.2.2 Observations about innovation processes

A number of important observations of a general kind were 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. 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 compliment, 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 twenty hectares to two thousand 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 in Scotland 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)

Indeed, evolution – or adaptation to local and changing circumstances – is a big part of the innovation process. Interestingly, though, this doesn't 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]

Also consider a West of England-based 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)

Not only does this represent an interesting source of innovation – on-farm experimentation– 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.

1.2.3 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 & infrastructure*
3. *Management*
4. *Marketing*

1.2.3.1 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 in Scotland:

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 Elsanta... (25)

... to carrot producers in the English Fens, utilising an “old” product:

The Chantenay 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.

1.2.3.2 Automation, engineering & 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 more 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:

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)

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...

As an infrastructural innovation, polytunnels have spawned "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 elsewhere.

1.2.3.3 Management and practices

Innovation associated with how operations are managed or an on-farm practice, 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 research 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 a Kent-based 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 precedes the adoption of any new practice or product, making management an important component of the innovation process.

1.2.3.4 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 1.2.2, 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. 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.

1.2.4 Impact & 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 Scottish 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 research relevant for the industry, the notion of impact and its measurement is of practical concern. As one representative 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 Welsh horticulture 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 the fact 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.

1.3 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.

1.3.1 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 oligopic 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 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 a representative of a major retailer 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/or greater control over the growing environment:

So for instance one 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.

1.3.2 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 labelling, 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 being- 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... you've got to make sure your sourcing strategy enables you to get the very best quality product you can. (33)

It also appears that supermarkets can play a significant role in 'challenging' others to innovate.

1.3.3 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).

... 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 below). 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 accepted by depots, to actually differentiate between beneficial insects and pests. (29)

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

1.4 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 often 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.

1.4.1 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 fifty-five thousand quid, and we didn't have fifty-five thousand quid... I sought of ordered it without asking him [laughs]. But this machine completely revolutioni- has, completely revolutionized carrot production since the late nineteen eighties, so... within three years if you didn't have one you weren't in the carrot industry anymore. (1)

1.4.2 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. 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 1).



Figure 1. 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).

1.4.3 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 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 Driscoll 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 1.5.1.

1.4.4 Formal research

The role of formalised 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 them 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 1.5.1.2) 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.

1.5 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).

1.5.1 Positive interfaces & 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.

1.5.1.1 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... (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).

1.5.1.2 The role of different organisations & 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.

1.5.1.3 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 privatization 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)

1.5.2 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 discuss 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 [public extension service] 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 1.6.

1.6 Industry ‘bottlenecks’

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

1.6.1 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, 2015) . Where the literature refers to ‘blocking mechanisms’ and ‘systemic problems’ or ‘failures’, it general indicates an issue of this nature (Lamprinopoulou, Renwick, Klerkx, & Hermans, 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.

1.6.1.1 Fragmentation

Fragmentation refers to the weakening of structural conditions 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 [levy board] model where we've got all the Agri-techs, and the HIPS, you know the NIABS, and the- erm, [levy board] 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 formalised research in the fresh produce innovation system also came under scrutiny.

1.6.1.2 Formalised research

Several barriers to innovation are found within formalised research structures. Aside from the privatization 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 above, 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 Arabidopsis, 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 of 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)

Of course, translational activity may well be needed at more than one stage of the innovation process.

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, too- you know have the success and move on, you're almost looking for different things than 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, 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 isn’t 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-chemicals, 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.

1.6.1.3 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 centred 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 hat 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 approach, are less mutually beneficial and can either impede or at least discourage innovative activity.

1.6.1.4 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 gravest barriers to innovation in the UK fresh produce industry.

1.6.1.5 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 1.8.

1.6.2 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)

... the timeline is difficult, 'cos we're dealing with biennial crops, so you're sort of saying to the government "well in about ten years time... we might have something" (30)

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 thing. (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 consolidated than those systemic barriers identified in the previous section.

1.7 Enabling factors

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

1.7.1 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 James Hutton. 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, 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 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.

A further theme explored the notion of *value*, and, in particular, creating the right conditions amongst stakeholders to realize the benefits of change; this often involves balancing the complementary or competing interests of numerous people and ensuring a multitude of factors are ‘aligned’:

... making sure that as you move produce from source through the trade to retail, that it still has, you know, shelf-life and consumer attributes associated with it so that people want to buy it and eat it... and from a competitive perspective, you know there's the economics of that that make it important in terms of driving value, making sure that different players in the chain can make a living in the broadest sense from it. (10)

So there's always a balance between- for me there's a sort of circle where for sustainable product development, it's got to go up through everyone through the supply chain... and I could have the nicest eating strawberry but if the yield is fifty percent of the reference, it's unlikely that the customer's gonna pay fifty percent more for it over the long term, and so it'll have a finite life. So there's this trade-off between agronomic yield, disease resistance, harvestability, then through the supply chain, post-harvest, and then through to the customer, what it looks like, what the texture is, what it tastes like, what its health and nutritional benefits are and the sweet-spot is trying to find something that ticks the box for everyone, rather than it being "oh it works for the grower but not for the customer or vice versa" and I think that for me, that collaboration, where you can get really- everyone happy to grow it, and ship it, pack it and sell it, then those are the things that generally stand the test of time. (33)

Enabling innovation, at the systemic level, involves interactivity. The building of networks and platforms can facilitate this interactivity. Likewise, certain policy choices may yield a more favourable situation for innovation. Quite apart from Section 1.6 (*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.

1.7.2 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.

1.7.2.1 Interactivity

As should now be clear, innovating actors most commonly rely on a personal and professional network of peers and people in the innovation support 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.

1.7.2.2 Human & 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)

... you've got to try and involve everyone and we try in here to come up with ideas and share them with our management team and we have a two weekly meeting a discuss it and we discuss it with our directors... (26)

I think at the end of the day it's the growers who have the practical issues to solve whether they're financial or agronomic, and... again the ones that have got the resource to do it they will say "this particular thing is not working for us, how can we do it differently? What is there out there, what could we do? Could we try something different on a small-scale, if it works can we scale it up?" (15)

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.

1.7.2.3 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)

I wish Hugh Fernly-Wittingstall would pick that up and run with it, 'cos the biggest number of complaints that I get for foreign bodies in my job is for pests being found and the number of them [that are] beneficials... (29)

Yeah they want to see it demonstrated and ideally demonstrated by a champion farmer near them. 'cos if John Smith's doing it, it must be good. (8)

So again, I suppose the word- using a management term, gatekeeper, the gatekeepers are very important... at each stage. (6)

Agronomists fulfil 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)

... again if you go back to the days when there was lots of small producers then you has a Darwinian competition between the advisors as well, for each sector there might be ten or

twelve ADAS advisors, but for each sector there was one sort of really- the one that rose to the top. (19)

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.

1.7.3 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)

And it's so true, and it's still true, and if you look at where we are successful in partnerships, and innovation, it's where we get together with people where we do have that commotion and we build trust. (31)

... 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.

1.7.4 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)

... there's an awful lot of knowledge and information, back in the past that's been lost. And when you go back and look at a lot of these things, they've all been looked at before. And in some instances they've been dismissed because we didn't have the technology to do it at the time. (15)

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.

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.

1.8 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 (then ADAS) 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)

Of particular concern for researchers is the model of competitive bidding that replaced what was once guaranteed research funding (due at least in part to the administrative burden this incurs):

Codswallop, the whole system is. 'cos it's got a huge amount of administration involved, whereas before in ADAS it was more sort of straightforward, you didn't have all this competition. (6)

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.

1.9 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)

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 outlined in this chapter were considered challenges in their own right. The loss of expertise for example, continue to be seen as threats 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.

Discussion

Here, the findings of the research are contextualised and some recommendations are derived from both the findings and consultation with the appropriate literature.

We find a close fit between the predictions of the AIS approach and the findings of this research: an AIS 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 et al., 2015, 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. We have discerned a number of ways that this arrangement has determined – for better and worse – the way agents interact, share, exchange and use knowledge.

We have several tools from the AIS approach to further this analysis, namely, the structural functional assessment. Turner *et al.* (2015, p. 2) provide a useful breakdown of the “functions and structures” of an AIS – also outlined by Wierzorek & Hakkert (2007), Kebebe *et al.* (2015) and Suurs (2009) – that can be adapted for the purposes of this discussion:

1. *Entrepreneurial activities* use the potential of new knowledge, networks and markets to create value (see Klerkx & Leeuwis, 2008). 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 policy and favourable market conditions) and “out” (by increasing the number of users). In other words, to further support the “co-evolution of social, technological, institutional and market changes” (Turner *et al.*, 2015, p. 3). An emphasis on the importance of innovation ‘platforms’ and networks where this interactive learning can occur is common in AIS literature.
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.* stress that ‘innovation agendas’ can be used to this effect, though in the UK fresh produce industry there is no unifying innovation agenda (discussed below). Mylan *et al.* (2014, p. 22) also note that shared meanings, expectations and clear future vision 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 and 3) financial infrastructure such as grants, subsidies and financial programmes.

A number of 'types' of system failure exist between these structures and functions (see Klein Woolthuis, Lankhuizen, & Gilsing, 2005). These can relate to *presence* (i.e. there is a lack of some instrument), *quality* (i.e. an instrument exists but is not fully effective) or *capability* (i.e. the inability of some actor to achieve a desired result). The relationships between these functions and structures can be used as a means of framing further discussion, and offer a chance to align barriers with their corresponding enabling factors – if they exist – from this research and relevant literature.

For example, a common problem that was felt to have had a cascading effect on other parts of the fresh produce industry is *horizontal and vertical fragmentation*. Horizontal fragmentation refers to a lack of communication or coordination between organisations and firms of the same type, whereas vertical fragmentation refers to a deficit of communication or coordination between hierarchical institutions (from Government 'down'). Privatisation of formerly public extension services has led to fragmentation in several countries in Europe (Hermans, Klerkx, & Roep, 2015), creating pluralistic advisory systems (Klerkx & Proctor, 2013) and a host of secondary problems such as:

- *Information/knowledge/power asymmetry between actors*
- *Lack of industry-level research/policy coordination*
- *Lack of formal processes for translational activity*
- *Acceleration of industry consolidation*

Having been noted elsewhere – in the Netherlands and New Zealand, for instance – measures can be taken to stem these problems. As noted in Table 4, innovation platforms that promote specific technologies (such as HortLINK schemes) or offer opportunities for people from different sectors to interact provide a tool for guiding innovative activity.

Other systemic problems identified in this project include:

- *Divergent innovation agendas* calls for the identification of common problems: given the disparities between larger and smaller firms, the ‘common ground’ for knowledge development is shrinking; yet stands to benefit both and avoids issues of intermediary services being used primarily by firms already capable of innovation (Klerkx, de Grip, & Leeuwis, 2006).
- *Globalisation of innovation systems*: fresh produce firms are now, like many other organisations, not bound by national limits (unlike certain innovation-support services) creating a mismatch in terms of power and representation.
- New forms of *supply chain management* are needed: information asymmetries between suppliers and customers hamper the innovation process, and relationships characterised by antagonism – rather than trust – do not support change (Mylan et al., 2014).
- *Cognitive gaps and demand articulation* are common issues: a recurring theme here and elsewhere is that people from different professions have different languages, incentives structures and norm (Klerkx & Leeuwis, 2009).
- *Lack of formalised translation processes constitute bottlenecks*: a market failure is evident where few formal mechanisms for the translation of research between basic and applied research, the various fresh produce sectors and in some instances between science and the wider industry.
- *Bolstering interaction is a common solution to innovation system problems*: interaction and learning by doing are paramount to innovation (Leeuwis, 2000) However, producer organisations and study tours offer the means to facilitate both interaction and knowledge diffusion.
- *No “one size fits all” approach to best practice/extension*: a gradient of knowledge – from the very discrete, observable-in-use and context-independent, to the tacit, hard-to-observe and system-dependent (Herstad, Aslesen, & Ebersberger, 2014) – ensures that there is no hard and fast rule for “delivering” knowledge to third parties.
- Despite the number of ‘systemic’ barriers to change identified in the Findings section, strong emphasis was placed on the entrepreneur themselves for finding appropriate networks, knowledge, and adding value to their businesses (Klerkx, Aarts, & Leeuwis, 2010).

By cross-referencing these problems with existing literature and comparing the barriers to innovation with enabling factors for change, it is possible to devise a series of recommendations – systemic ‘instruments’ – to tackle some of these barriers (see Table 4).

Table 4 A structural/functional analysis of the innovation system of the UK fresh produce industry with suggested systemic instruments for change

<i>System function</i>	<i>Structural element</i>	<i>Problem “type”</i>	<i>Description</i>	<i>Suggested systemic instrument</i>
<i>Entrepreneurial activities</i>	Interactions	Quality	Knowledge & power asymmetry between customer and supplier	New forms of supply-chain governance
	Actors	Capability	Some actors have insufficient resources to undertake innovation	Risk capital
<i>Knowledge development</i>	Institutions	Presence	Fragmentation due to no nation-wide oversight of research activities	Innovation platforms, establishment of coordinating body
	Interactions	Quality	Reactive steering groups	Demand articulation, widen participation, pooled, cross-sector projects
	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

<i>Knowledge diffusion</i>	Infrastructure	Presence	Loss of funding and facilities has diminished opportunities for interaction	Focus on intermediary/broker organisations, innovation platforms
	Interactions	Quality	Cognitive gaps limit the quality of interactions between actors; different incentive structures between professions causes a mismatch in goals	Cooperative research programmes, intermediary/broker organisations
	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-handling practices and succession planning	Centralised data-basing
<i>Guidance of the search</i>	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

<i>Market formation</i>	Interaction	Quality	Information asymmetry between suppliers and customers with regards to market development	Bridging instruments, collaboration schemes
<i>Resource mobilisation</i>	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
<i>Creation of legitimacy</i>	Interaction	Quality	Researchers not rewarded for engagement with industry, lack of mutual understanding/trust preventing	Cooperative research programs

Knowledge and Technology Transfer

- As part of the project, a paper on *Agricultural Innovation: Lessons from Medicine* was presented at the annual *KES Innovation Through Knowledge Transfer* conference held at Staffordshire University, April 2015. The paper examined what lessons the agricultural innovation system (AIS) in the UK could learn from its equivalent in biomedical research and is available in the online edition of the conference proceedings: <http://nimbusvault.net/publications/koala/inimpact/papers/inkt15-015.pdf>
- A talk on the evolution of extension theory and practice was presented at the AAB *Knowledge Exchange: from research to the food supply chain* conference at the University of Lancaster, in June 2015.
- A poster describing the project has been presented at the AHDB-organised *Smart Agriculture Conference* in Birmingham in 2015, the *AHDB Student Symposium 2015*, and at the University of Warwick School of Life Science *Postgraduate Symposium 2016*.
- Two talks summarising this research have been given at two consecutive AHDB student symposia, as well as at the University of Warwick School of Life Sciences student symposium (2017)
- A summary of a paper was delivered at Oslo University's *Global Food Governance: Influence of Non-State Actors* doctoral course in summer 2016.
- A presentation summarising the main results of this project was presented to the Royal Horticultural Society annual symposium in November 2016.
- A final talk related to the use of the AIS approach in agricultural systems research is due to be given in July 2017 as part of the European Society for Rural Sociology's biannual congress.

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