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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

The nature of innovation in the UK fresh produce industry is complex, but an intensely competitive marketplace, coupled with a pronounced entrepreneurialism and increasingly globalised innovation network, ensures strong innovation capability.

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 a range of barriers across the fresh produce value chain, both personal and institutional, that slow or prevent new knowledge and innovations from making impact.

The aim of this project is to identify sources of innovation in the fresh produce industry – where it comes from, where it goes and how it is adapted, and the barriers that exist to its creation, spread and implementation. To do this, an initial study was undertaken to interview industry experts and a more in-depth case study is planned for the coming summer.

By the completion of the project, we will have a better understanding of innovation in the fresh produce industry; it will be possible to provide recommendations to improve innovative capacity, and relevant knowledge generation and exchange. In turn, this will provide industry with more timely and relevant interventions and foster a more innovative sector.

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.

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 Knowledge Transfer for Innovation 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 (Gale, Heath, Cameron, Rashid, & Redwood, 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:

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

Findings

With the post-war consensus on increasing yield through agricultural science largely achieved, and with agricultural research now primarily organised along demand-driven lines, new problems have emerged with regards to the role of research within agriculture; sometimes called 'knowledge mobilisation' and how this connects to innovation. The study of innovation is not only concerned with formal research, however, there is a growing recognition of the importance of private enterprise, non-governmental organisations and producer organisations which has shifted government and academic focus to these actors.

At the time of writing, 30 semi-structured interviews have been undertaken, in most parts of the UK with a range of people across all levels of the fresh produce sector. In total, ~60 emails were sent to prospective interviewees indicating a 50 per cent positive response rate (with several of those still representing possibilities for interviewing).

Although the transcription, coding and analysis of interviews is on-going (and as such the categorisation and interpretation of themes may change), several descriptive categories are emerging:

1. Nature of fresh produce industry
2. Drivers of change
3. Nature of innovation and examples from the industry
4. Sources of innovation
5. Enabling & disabling factors for innovation
6. Forms of communication, organisation & collaboration
7. Responsibility
8. Challenges
9. Comparisons with the past
10. Areas for future innovation

The first five of these topics are discussed in more detail in this report with evidence from interviews and existing literature used to highlight key themes. However, **analysis of current categories is on-going** and as such the descriptive accounts of these themes given here are subject to change. Many of the categories have overlapping components; for instance, the competitive nature of the industry is assumed to be a *driver* of innovation, and something that *disables* innovation. Further analysis is required to interpret linkages in the data and explain phenomena within these descriptive categories.

1. Nature of the fresh produce industry and sector trends

Many observations were made by interviewees concerning the *nature* of the FPI 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. For example, the ease with which protected cropping environments can be manipulated was seen by some as lending to the innovativeness of the industry. A strong vein of entrepreneurialism also appears to define the industry, and as such innovation is given a high priority amongst businesses that can mobilise knowledge effectively.

2. 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.

3. Nature of innovation and examples from the industry

A wide range of specific innovations and opinions on the functioning of innovation in the industry were discussed during the course of the research. A very common observation was that polytunnels had revolutionised soft-fruit growing (and were now seeing use in top/hard-fruit production), spawning subsequent innovation to better meet the needs of this ‘new’ growing environment.

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. Enabling and disabling factors for change

A wide range of ‘enabling’ and ‘disabling’ factors for change were observed during the interview stage of this research. Since the 1950s a large number of publications have sought to delineate what influences the adoption of innovation at farm level (known as *extension science*), and many of the observed determinants of change in the modern UK fresh produce industry are similar to those highlighted in extension literature over the years (particularly where the focus is on the primary producer). However, there are a number of factors seemingly unique to the industry that can influence innovation.

Discussion

The nature of innovation in the UK fresh produce industry is complex; through interviewing a range of industry experts, we have begun to provide answers for several of the project's research questions (see Appendix), as well as start to contribute to an Agricultural Innovation Systems (AIS) analysis of the sector.

The nature of the industry itself seems to determine innovation outcomes; the pressure of the marketplace, coupled with an entrepreneurialism, which other sectors of farming are accused of lacking, drives innovation. As such, innovation is seen to be ubiquitous, occurring across the value chain. A few notable sources of innovation are emerging from the data, however, with research institutes – both here and overseas – certain private businesses and producer organisations – based in the UK and elsewhere – and even smaller growers playing a part. Further work will clarify how these innovators operate in the innovation landscape of the UK fresh produce industry.

In addition, there are a number of personal barriers to innovation – often those previously identified in extension science literature – and institutional barriers to innovation that, in the case of the fresh produce industry, result in unique challenges. One important descriptive coding category – *forms of communication, organisation and collaboration* being its working title – is yet to be interrogated in a meaningful manner, but should offer a detailed analysis of how the various actors that make up the fresh produce industry interact with regards to innovation.

The results of this exercise (and further research is planned) point towards a heterogeneous innovation 'landscape' with many contributions from many parts of the supply chain, with a similarly diverse range of barriers to innovation largely dependent on business scale and area of expertise. There do seem to be grounds for cooperation, however, and we are also witnessing an 'internationalisation' of the agricultural innovation system in fresh produce.

Financial Benefits

At this point, we cannot determine the financial benefit of a given method or policy recommendation. However, the value of improving the innovative capacity of UK Fresh Produce stands to be large. Improving best practice across the industry alone will yield a more valuable and productive sector.

SCIENCE SECTION

Introduction

This project aims to identify the sources of innovation in the UK fresh produce industry, determine which factors contribute or impede successful innovation and how we might build innovative capacity in the industry.

Historically, innovation has been studied as a branch of economic theory related to *growth*. Today, however, it is studied as a phenomenon across a range of disciplines such as economics, management, sociology, science and technology studies, and history (Malerba & Brusoni, 2007). Recently, 'systems thinking' has found a home in the study of innovation, examples being found in Edquist & McKelvey (2000) and Elzen *et al.* (2004), a key assumption of the latter being that greater efficiency can be achieved by optimising the socio-technical 'system' in which innovation occurs than by 'incrementally' improving 'technological artefacts' of that system. Elzen *et al.* note that this focus is wider than seen in industry or sectoral systems of innovation research in which the user-side is taken for granted or narrowed down to 'the market' as a neutral selection environment for innovation.

The study of innovation in agriculture has been strongly associated with the study of agricultural research and extension science, with successive conceptualisations of the role of research in agriculture. However, agricultural research as undertaken at research institutions today is seen as just one component of an ever-changing agricultural system, in which heterogeneous actors (farmers, producer groups, processors, retailers, researchers and input industries for example) determine both technological and non-technological innovation outcomes. This is understood through an increasingly applied framework known as Agricultural Innovation Systems (AIS). Agricultural systems can be regarded as Complex Adaptive Systems (CAS) that are self-organising and host to not only technological development, but to *"… institutional change, supply chain reorganisation, market development and creating social acceptance"* (Klerkx, Aarts, & Leeuwis, 2010). It is suggested that, as such, the properties of the system,, be the focus on barriers to innovation or an entirely different issue, cannot be analysed in isolation (Klerkx et al., 2010). With respect to this, AIS publications "… emphasise the need for improved coordination, collaboration and communication between actors in the agricultural system as a recondition for innovation" (Schut, Rodenburg, Klerkx, van Ast, & Bastiaans, 2014, p. 104).

It has been noted that in recent years the agricultural sector in industrialised countries has been orientated along demand-driven lines, while at the same time previously public research and extension institutions have been privatised. In the market that has emerged for services supporting agricultural innovation, so-called 'market failure' has led to both supply- and demand-side parties having trouble "affecting transactions" and establishing the necessary relationships to make demand-driven innovation processes work (Klerkx & Leeuwis, 2008a). A recent political drive in the UK (and elsewhere) to foster innovation in 'biological-based industries' such as farming (BIS, 2013; see UK Government, 2014) comes at a time when observers have noted a similar, systemic failure to 'move' basic scientific research forward into impactful innovation (Pollock, 2012).

In a practical sense, the emphasis of AIS traditions on interactivity shifts the focus from the spread of individual innovations, as it was with Roger's *Diffusion of Innovations* (1983), to how actors shape a network of support to achieve their individual and collective goals (see Engel (1995)). "Innovation networks" rely on many other peripheral actors within their *institutional environment* and reflexively monitor changes to that environment stemming from either their own or other parties' conditioning of the system (called *mutual embeddedness* (see Edquist & Johnson (2005) and Markard & Truffer (2008, p. 598)). As Kash & Rycroft (2002, p. 583) explain, such self-organising networks are "… responses to the inability to innovate complex technologies with yesterday's simpler, hierarchical organizational structures and processes". A perception of increasing costs, time pressures and ever more complicated technical systems drives the spontaneous formation of these networks (forms of which are evident in the UK fresh produce industry). Networks help meet these challenges by connecting individuals and groups, to leverage the skills and knowledge required for complex innovation (Kash & Rycroft, 2002).

Innovating parties are, of course limited (or *bounded*) in their ability to shape their environment; their influence will, presumably, not be absolute and institutional environments can be altered externally.Consumer preference, policy and market factors, for example, constitute sources of *structure variation,* hampering the efforts of actors to reduce the inherent uncertainty associated with innovation (Klerkx et al., 2010).
Indeed, Engel (Engel, 1995, p. 9) observes that uncertainty is an irremovable component of innovation:

"And to what extent may we attribute what actually happens to the way in which the actors organized themselves and their individual or collective actions? Eventually, I would like to ask myself which of the actions were most relevant to achieving the changes observed?

*Clearly, I take innovation to mean **'change-on-purpose',** propelled by individual and collective intentions. However, given the discussions in the previous paragraphs, the reader may not expect me to believe in a straightforward causal sort of relationship between intentions and effects. To the contrary, my field experience and studies have convinced me that even searching for a simple causal relationship between what actors **intend to do** and **what they do** is problematic, let alone between what they intend to do and **what the eventual results are."***

As Meijer *et al.* (2007) demonstrate there are many forms of uncertainty for innovating actors; this includes *knowledge* (see Table 1), which Klerkx *et al.* (2010, p. 391) consider to be *ex ante* or unpredictable to some extent.

Type of uncertainty	**Issue**
Technological	• Characteristics of the innovation, such as cost or performance • Relation between the innovation and the infrastructure in which it is embedded • Uncertainty as to what adaptations to the infrastructure are needed • Possibility of choosing alternative, future options
Resource	• Amount and availability of raw material, human and financial resources • How to organise the innovation process (in-house or external R&D?)
Competitive	• Behaviour of (potential or actual) competitors and the effects of this behaviour
Supplier	• Actions of suppliers with regards to timing, quality and price of delivery
Consumer	• Consumer preferences with regards to the innovation • Long-term development of demand over time
*Customer	• Behaviour of (potential and actual) customers to the innovation (i.e. what value will the customer derive from the innovation? Will it be fair?)
Political	• Current policy or changes in policy, as well as affect of policy, regulation or lack of regulation, and reliability of governance

Table 1. Uncertainties in innovation, adapted from Meijer *et al.* (2007) and Klerkx *et al.* (2010). *"Customer" category added by author due to observations from data collected as part of this project.

Indeed, we see examples from the data so far collected in this research of actors forming and collaborating with support networks to reduce the uncertainty of innovation through the generation of knowledge (see 'Findings' section).

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. A brief summary of the conclusions of this work are given below, but the full paper, which was presented at the Knowledge Transfer for Innovation conference in Staffordshire in 2015, is available online (see *Knowledge & Technology Transfer*, below).

The first stage of 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 interviews were recorded via Dictaphone, transcribed and 'coded' through *Framework Analysis*, a qualitative research methodology increasingly used in medical and health research (Gale et al., 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 the whole interview and any contextual or reflective notes.
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 phenomena, 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:

6. *Innovation in the FPI*
7. *Barriers and Facilitation of innovation in the FPI*
8. *Contribution to innovation in the FPI*
9. *Representation in the FPI*
10. *Challenges for the FPI*

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

At the time of writing, 30 semi-structured interviews have been undertaken, in most parts of the UK with a range of people across all levels of the fresh produce sector (see Table 2). In total, ~60 emails were sent to prospective interviewees indicating a 50 per cent positive response rate (with several of those still representing possibilities for interviewing).

Interviewee category	**No. of interviews**
Seed producer [vegetables]	1
Grower [edibles]	7
Grower [ornamentals]	1
AHDB	1
Producer group/marketing group	2
Researcher	8
Policy	1
Agronomist/consultant	3
NGO	3
Retailer	1

Table 2. Numbers of interviewees interviewed by employment category. It should be noted that many individuals interviewed have been involved in more than one part of the industry during their careers, and employment category refers only to their role at time of interview for purposes of ensuring that diverse views were heard. Two interviews were undertaken in the Netherlands to speak with experts in *agricultural innovation systems* analysis (both under 'researcher' category).

Although the transcription, coding and analysis of interviews is still on-going (and as such the categorisation and interpretation of themes may change), several descriptive categories are emerging:

1. Nature of fresh produce industry
2. Drivers of change
3. Nature of innovation and examples from the industry
4. Sources of innovation
5. Enabling & disabling factors for innovation
6. Forms of communication, organisation & collaboration

7. Responsibility
8. Challenges
9. Comparisons with the past
10. Areas for future innovation

The first five of these topics are discussed in more detail below with evidence from interviews and existing literature used to highlight key themes. However, analysis of current categories is on-going and as such the descriptive accounts of these themes given here are subject to change. In this sense, the observations below serve as an example of the type of data that can be generated by the methodological approach used in this study.

Many of the categories have overlapping components; for instance, the competitive nature of the industry is assumed to be a *driver* of innovation, and something that *disables* innovation. Further analysis is required to interpret linkages in the data and explain phenomena within these descriptive categories. What follows is based on the categorisation of data from ~15 interviews and mixed levels of analysis.

Nature of the fresh produce industry and sector trends

Many observations were made by interviewees concerning the *nature* of the fresh produce industry (FPI) and 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 both its institutional landscape, innovation needs and outcomes (innovation *demand* and *supply* as Klerkx and Leeuwis define it (Klerkx & Leeuwis, 2008b)):

1. Most interviewees see the UK FPI as being *inherently* innovative, either due to the innovativeness of growers and other entrepreneurs or through necessity in an extremely competitive market place in which actors must 'innovate or die' (see 'drivers of innovation' below). As one soft fruit grower in Scotland noted:

   I think it's inherent. We've got it in our blood, definitely… and I suppose with polytunnels… there is more, I don't know, just technical things that you can… you can invent things.

   A senior researcher in the Netherlands also felt that the 'innovativeness' of horticultural production – at least in protected cropping – stemmed from the ease with which environments can be manipulated and the continuous, year-long production of certain crops that permits constant experimentation. The grower quoted above stated that it was the complexity of horticultural growing systems (involving technical innovation such as

machinery, tunnels and varietal improvement) and number of interfaces with other actors (packhouses, labour organisations) that provided the opportunities for innovation (compared in this case with arable farming). An almost perpetual search for improvement was, for many interviewees, a defining characteristic of the industry.

2. The large number of (minor) crop types that fall within the remit of support organisations (such as AHDB) means that research funding is spread thinly between those crop types; the perceived lack of funding for certain crops is a source of tension between several FPI actors. As a result, much of the innovation in the various FPI sectors proceeds along evolutionary lines[*], with disruptive innovation coming from entrepreneurs (and a perception by those 'left out' of research programs that private businesses are the sole providers of knowledge for innovation).

3. Another area of tension concerned the competing demands of long vs. short-term thinking and processes and the respective 'working paces' of different types of organisation; it is not clear precisely how innovation outcomes are determined by the differing 'timescales' and pace that the various actors in the industry operate on, but reference was made to the short-term, reactionary demand of producers and the need for strategic vision:

   I think in the UK, people like you know, the Agriculture and Horticulture Development Board play a pretty big role in trying to carry some of the longer-term research needs and almost insulate them from the sort of short-term knee-jerk reactions, you know, "my biggest problem this year is virus", well next year it might be we have a hot warm summer, so it's fungus.

   The insufficient time given to (public) research projects compared to commercial research programmes in the private-sector:

   We don't have enough long-term investment in science streams, you know, three year science grants in a crop system is pointless… if you look at what commercial

[*] 'Evolutionary' or 'incremental' innovation generally refers to gradual improvements made to an existing system – be it an engine or a farm – whereas 'revolutionary' or 'radical' innovations refers to innovation that changes *how* that system functions in a fundamental sense; however, this is only one way of defining types of innovation. Elzen *et al.* (2004) provide a different breakdown (see Appendix).

companies do when they're trying to bring in new varieties into their sourcing portfolio... erm, without giving too much away, I can tell you that for some crops, to bring a new variety in and to scale it is a ten year process, and there's a reason for that, which is you go back to that mitigating risk thing, and I think that that's a good example of the timeframe paradox that there is between - well I fund a piece of research for years, but actually if I'm gonna take advantage of an output, it'll take me a decade before I fully realize the opportunity.

The juxtaposition between the 'pace' of the research establishment compared to private businesses:

… we had a disease appear which we weren't too familiar with so somebody said "phone HDC" 'cos I think at the time they were doing some research or something on this particular pest. So we phone them up. It was in the middle of the summer, 'cos that's when our production... and the person involved in the research at the time was on holiday for three or four weeks... and there was nobody else to help. So we had to sort ourselves out.

4. The relatively small market size of the industry (compared in the main to the arable sector) and minor status of horticultural crops in the UK deters increasingly expensive investment in research, approval of active ingredients, and machinery. As a leafy salad grower noted:

   … 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. But for somebody who does it in Italy, then he'd be doing OK.

   This stands in contrast to certain other firms who now manufacture their own harvesting rigs, presumably having met the economies of scale required for such investments – in terms of time, expertise and finance - and having found no suitable alternatives either domestically or internationally for their sector (see *nature of innovation and examples from the industry).*

5. Consolidation of the industry (*rationalisation*) has left certain firms holding significant market share (sometimes close to one hundred per cent in some crop types) with knock-on effects in terms of innovation supply and demand; such firms can invest in

their own machinery development, provide substantial funding for research pertaining to their own innovation needs and 'shop around' for innovation support. The ability of larger organisations to direct research agendas – to a greater extent than smaller organisations and individual growers – was also seen as a factor disabling the kind of innovation that might favour smaller organisations. Such consolidation of the market, coupled with pressure from retailers means producers are forced to either 'scale-up' their operations to remain competitive or identify and supply niche markets. As a former (AHDB) levy-payer turned direct-sale (farm shop) grower noted:

I made a conscious decision in ninety seven to not sell anything wholesale again… and so we put grass back down, expanded the range of vegetables that we grew, 'cos by the time I finished I was only growing four niche-market product vegetables and they were competing with, you know, one was [name of Italian company], and would come off a forty foot semi trailer at the wholesaler that I used to take my van-load to, and look like it was cut a lot sooner than mine and it had come from Italy, 'cos it had been vacuum-cooled, into a chiller wagon, so... really we couldn't compete.

6. Indeed, the high capital cost associated with much of the physical infrastructure required for large-scale fresh produce production and processing was recognised by many as constituting a barrier to continued innovation. In turn, there appears to be a strong *divergence in both the innovation demands and pathways at different scales* (business size), including, for instance, the level of involvement in research:

And a lot of them, particularly the smaller ones who are perhaps less involved in the industry look at as it's 'just a cost'… which they don't see the benefit 'cos they don't appreciate perhaps the background and the necessity of certain bits of work. You look at the bigger growers and the more integrated they are with research… they understand the cost of research and understand the importance of the kind of work the HDC has been doing, and do think it's very good value for money.

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 the marketplace. Several of the drivers mentioned are given below:

1. Growers – as mentioned above – are perceived to be inherently innovative and experiment with improved methods of farming; and as such are by nature driven to change. However, other interviewees took the view that growers are resistant to change and that the industry is, rather than being inherently innovative, deeply conservative (in the sense that new ideas are treated with scepticism). It is not clear how either of these two mutually exclusive views can be corroborated or refuted, but does speak about the competing views on the so-called problems and challenges within the industry; how an individual views the grower community may shape their attitude towards problems and solutions in the industry.

2. Many interviewees saw the UK fresh produce marketplace as intensely competitive; more than once Darwinian 'natural selection' was invoked to describe the difficulty in maintaining competitiveness, with 'innovation' being cited as a means to stay competitive:

   Erm because effectively the competition that exists within the market place - if we miss out [on] an opportunity to innovate and develop, then it provides options for other people to do the same and then [they] will take our marketplace.

3. More specifically, high labour costs (at the production end) are a key target area for innovation in order to reduce costs and remain competitive. The prices 'back' to other actors, as determined primarily by supermarkets (who in the case of the 'Big Four', vendor some 75% of UK fresh produce and are the main 'customer' of producers, packers and processors) are seen as suppressed; this "price pressure" is seen almost universally as a barrier to innovation (see 'barriers to innovation'). However, it was often acknowledged that it was the competitiveness amongst the leading supermarkets themselves that caused such price suppression, pushing an 'efficiency agenda' back up the supply chain. As one interviewee noted:

   They push it to the grower. This is one of the problems… if the grower comes up with an innovative way of doing something which potentially increases their profit margin,

eventually that will get squeezed up again as the retailer tries to squeeze that out of them.

Others framed the effort to increase efficiency and reduce costs, across the entire supply chain, as being 'challenged' to innovate by different supply chain actors. Such 'challenges' are not unique to the retailer; producer organisations, which take a number of forms, also act as both a conduit of innovation and fora in which to 'challenge' participants to innovate. In a similar vein, one grower suspected the lack of notable subsidies available to fresh produce growers ensured the industry remained more innovative than the arable sector (which is seen in the main as "easier" thanks in part to the possibility of earning subsidies).

Nature of innovation and examples from the industry

A wide range of specific innovations were discussed during the course of the research, as was the nature or workings of innovation in the industry:

1. Innovation was, in general, seen to be either responsive to the market (aimed at reducing costs or increasing value), or responsive to policy (adapting to changing legislative environments or other policy, for instance). As an example of the former (and of the specificity of the fresh produce sector) one interviewee noted:

   … more in keeping with a typical industrial business, they see innovation and intellectual property as an opportunity to differentiate themselves in the market place. If they can get an advantage on their colleagues or on their competitors, that's what they're seeking to do… 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.

   It should be noted that varietal improvement and development. often the subject of the intellectual property mentioned above, is a key area for adding value, driven in large part by the needs of large retailers to have *points of difference* in their fresh produce offering to attract customers into their stores. However, more in keeping with the latter form of innovation, varietal improvement was also a key area in helping meet legislative requirements that had an impact on pest and disease control (the loss of active ingredients for pest control due to recent legislation was a particularly common complaint amongst growers and those researchers close to growers). Machinery and

processing equipment is also a key area of innovation for the larger horticultural businesses, reflecting their capital-intensive operations in which labour represents (by far) the largest share of their outgoings.

2. A recurring observation has been the dependency on interaction between individuals and across the supply chain for ensuring successful innovation, reinforcing the view put forward by Klerkx *et al.* (2010) that innovation is more than new technology, but a negotiation between heterogeneous actors. For example:

   If you don't have the marketing, you can do all the technical innovation and you'd have wasted your time, 'cos there's an assumption that you're going to get an award from that technical innovation whether it's just simply an efficiency or whether it's a new product grouping even.

   Successful innovation, as separate from 'invention', requires the creation of value (as mentioned above) and communication of that value to stakeholders; this, of course, is not always easy, and in some cases structural, systemic issues prevent actors from collaborating on innovation with outside actors (an issue of trust (see *enabling factors for change*)):

   Yeah. I think if you look how our dynamics works in terms of the supply chain, if... you innovate, 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.

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.

1. The sources of innovation in the fresh produce industry were commonly cited as being multifarious, indicative perhaps of the sense that the industry was somehow inherently innovative. More than one respondent claimed that innovation was "everywhere", with contributions from the shop floors of larger produce handling organisations to multinational agro-chemical companies. This, in itself, is reflective of the emphasis on 'other' innovating actors in systems approaches to innovation in agriculture: private and non-governmental organisations are seen as key components of innovation (rather than, say, strictly focussing on public institutions and researchers, and the issues faced by them). However, when probed, interviewees did begin to clarify types of organisation, and specific organisations, that they saw as being sources of innovation.

2. Several of the large, widely-known companies in the industry were commonly cited as sources of innovation; having interviewed representatives from such companies, they themselves are aware of their positions as market leaders (and their attitudes toward innovation are interesting in their own right). Organisations with sufficient resource – both in time and finance – have *options* when it comes to pursuing their innovation agendas. Many are well embedded within the 'formal' research architecture; executives and technologists sit on AHDB grower panels, providing them with some leverage to steer the national research agenda (which is not without issue, see *barriers to change*). Companies may choose to collaborate with third party organisations, public or private, depending on competitiveness and appropriateness, to develop solutions to their problems[†], sometimes funding PhD student projects and (in some cases) seeking to protect those solutions through intellectual property protection. They also undertake their own, in-house R&D where possible. As such, we can see these companies as *champions* of innovation, an important enabling factor for change (see below).

[†] It seems as though companies are open to collaboration with other actors, even competitors, on problems that are *non-rival* if they perceive the issue to be industry-wide (and with uncertain *excludability*), a strategy that can reduce their personal investment in developing a solution.

3. A very common observation was that innovation came from “overseas”; the Netherlands, Spain and USA were frequent examples, but UK organisations, both private and public, have established links with other companies and bodies in southern Africa, the Middle East and Oceania, and, in the case of some private businesses, undertake their own production overseas so as to better meet year-round market demand in the UK. The internationalisation of the agricultural innovation system allows for different kinds of experimentation, too. As a producer/packer based in Scotland noted:

   No the seed has been developed by a big company, a big multinational company who we have a strategic alliance with [abroad] *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. So I've picked out all the varieties that I think have got some potential for going forward, I've got seed of those varieties and put them into our Spanish trials and from there I will see how they develop and we'll take them forward again in Scotland the following year. So it gives us an extra year.*

   As the above example highlights, innovation does not only originate with overseas companies, to be either marketed by those companies in the UK or otherwise discovered by, for instance, a study tour, but from UK growers interacting with overseas producers and researchers, and using the opportunities presented by overseas production for experimentation and feedback. The relationships being established by UK growers and packers with overseas counterparts or other organisations is an example of the type of interactivity that can foster innovation suggested as paramount by AIS approaches.

4. Interestingly, while certain individuals, firms and other organisations enjoy a reputation as ‘innovative’, often being credited as the source of a specific innovation, several interviewees noted that contributions to innovation can be masked; agronomists are vital sources of knowledge for primary producers, but for a variety of reasons do not necessarily couple that knowledge with its ‘original’ source. In this case, the agronomist was the source of innovation, even if he or she did not develop the solution themselves (but, importantly, may have adapted that innovation to suit the specific context of their customer). As such, there may be a ‘disconnect’ between sources of innovation and *conceptions* of the sources of innovation in the industry, presenting both a problem of *perception* (organisations may not receive ‘credit’ due for the development of solutions by users of that solution, perhaps contributing to scepticism) and of *accounting,*

(organisations may have difficulty in demonstrating the impact of their R&D expenditure *even if* there has been impact as a result of their endeavours due to the diffuse nature of the spread of knowledge through the agricultural system). As a potato grower in Scotland noted:

You know - we have a strong grouping 'round here called [name of local, private agronomy company], who do trials and advice on cereals particularly oats and potatoes and I dare say we tackle other crops as well. But... [name] who's the MD of that 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 [name of agronomy company] brand.

As the above quote demonstrates, knowledge can move through the agricultural system decoupled from its provenance. While this is not surprising, it is clear that this presents a problem for those wishing to know from 'where' an innovation 'came'.

Enabling and disabling factors for change

A wide range of 'enabling' and 'disabling' factors for change were observed during the interview stage of this research. Since the 1950s a large number of publications have sought to delineate what influences the adoption of innovation at farm level (known as *extension science*), and many of the observed determinants of change in the modern UK fresh produce industry are similar to those highlighted in extension literature over the years (particularly where the focus is on the primary producer). However, there are a number of factors seemingly unique to the industry that can influence innovation.

1. No interviewee saw such factors for change as belonging purely to primary producers; in fact, considerable attention was given to the functioning of the wider agricultural system, with particular focus on the interfaces between various organisations. For example, the commercial relationship between producers, intermediary organisations and retailers was a key area of concern:

   … you need someone to say "well actually we understand that if we pay thirteen P a kilo for carrots instead of twelve P, that actually, to one of my customers, is worth forty four thousand pounds per month". OK. Multiply that by twelve. You could do a lot with that money, in terms of investing, research, welfare, whatever it is.

It was felt widely that return to growers had at best remained stagnant for many horticultural crops over the last few decades, despite the relative success of multiple retailers over the same period. This had in turn diminished producer investment and .driven many growers out of the market or into larger agglomerations. An example of how the 'institutional' environment determines innovation pathways; in this case forcing the creation of producer organisations to better bargain with retailers and consolidation across the industry, some growers choose to opt out of this relationship entirely (as mentioned earlier). Interestingly, consolidation of the industry was itself seen as an enabling factor for change. As noted above, many of the larger firms in the industry have a strong record on innovation. Likewise, this research has found strong evidence to suggest producer organisations, that can take various forms, also stimulate innovation amongst members, in part by providing fora for the championing of specific innovations.

2. It was felt, primarily amongst the research community and those involved in commissioning research, that there were problems in 'moving' basic, 'blue-sky' research into more applied avenues, with a reliance on serendipity rather than formalised processes. In part, this problem is political: the emphasis on molecular and '–omic' research was cited as an example of an institutional barrier that had diminished the resources available for strategic, applied research (perceived as having more immediate impact on industry). Interestingly, this is the reverse of the situation in US medical funding, where a growing preference for translational research that might take advantage of the advances seen in those same molecular and –omic disciplines has been seen as a threat to basic research funding and, by extension, the passion of those who 'do' science for the sake of a child-like curiosity (Weissmann, 2005). However, the supposed failure to translate basic research into practicable solutions was not a ubiquitous concern, but an issue for researchers who acknowledged the fact that some research funded by the levy boards never reaches the farming community. Also, a number of researchers noticed that research was being periodically repeated:

… what's his name [AHDB employee] has done analysis of HDC funding and they've funded the same thing over and over again, you know. And that's - that is one of the issues of short-termism as well, you lose core - sort of corporate knowledge. 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 [name of research institute]…

The loss of expertise in the research community has led not only to the loss of institutional memory, exacerbating the problem of research repetition, but also to a lack of the heterogeneity required by a diverse industry. Improving the efficiency of levy board funding allocation, so as to not repeat studies unless necessary, would of course provide benefit to levy payers by freeing-up resources for other projects that might have otherwise been 'wasted' (a worthy endeavour). It seems possible that even greater benefit could be derived from leveraging relevant basic research. However, it is not clear how this is best done. Reminiscent of the early attempts in health research to determine how much research is "lost", never utilised in a practical sense, and also which barriers exist to the translation of that research so as to ensure it isn't lost, the current way in which research feeds into innovation in the fresh produce industry isn't always clear. In large part the utilisation of knowledge seems to depend on *individual* researchers (in the same way that their knowledge of past research projects can help prevent the repetition of research). It is researchers familiar with the current state of science in a given field that are best placed to see opportunities for translational research. Interestingly, agronomists provide the same function, often translating the work done by research institutes and elsewhere into useable solutions for their customers:

… and we as agronomists, yes we are meant to give new ideas, but a lot of the time we're picking up ideas and we might be seeing them and it's giving us an idea and we adapt it and we present it somewhere else, or you know, it's something which we've seen abroad and we decided to bring it into the country.

One way of interrogating factors for change is to sub-divide them into 'structural', those that are a *direct* product of the system in which the fresh produce industry is embedded, and 'personal', those that are related to how an individual interacts with innovation, categories (see Tables 3 & 4). Of course, it could be argued that an 'enabling factor' is (merely) the reverse of a 'disabling factor', but they are presented below as separate 'issues' due to the level of analysis so far undertaken. More work with the data should be able to consolidate these observations thematically (and cross-reference them more thoroughly with observations from other research).

Structural	Personal
Lack of access to knowledge, exclusivity of certain projects, privatisation of knowledge	Lack of resource (time, finance)
'Nature' of certain sectors makes innovation difficult (mechanisation of soft fruit, for example)	"Bed blockers" (age, 'frozen behaviour', tradition, habit)
Institutional, wider economic setting not appropriate for some innovation	Lack of/misunderstanding of research needs, capabilities of research
Market resistance	Difficulty in 'demand articulation'
Regulation	'Fear' of failure
Research community follows its 'own agenda'	
Research favours some over others	
Return to growers (amount, timing) restricted by supermarket behaviour	
Loss of expertise in the industry	

Table 3. 'Disabling' factors for change based on ~15 'coded' interviews

As described in the '*Nature of the fresh produce industry'* section, it appears as though there is a disassociation between the needs of the industry at different scales (and crop type). Going forward, more work needs to be done to understand how substantial these differences are, as well as what this means for innovation in the industry.

Structural	Personal
Creation and communication of the value of change	'Attitude' towards innovation
Co-developed solutions provide stakeholders with incentives to use outcomes of research	Co-developed solutions provide stakeholders with incentives to use outcomes of research
Collaboration with other organisations can offset risk	People need to 'see' evidence of effectiveness
Consolidation of industry has enabled [specific] innovation	'Champions' – people able to shape others' opinions - vital for influencing change

Access to finance to help support innovation and reduce risk	‘Gatekeepers’ – those with the power to either block or advance innovation – play important role
Ability to ‘protect’ innovation through intellectual property protection	"Incentives” to change
‘Producer organisations’ promote innovation	Networking opportunities
	Need for scientists to understand industry needs
	Working cultures that support innovation
	Importance of personal relationships/networks
	‘Trust’ between actors

Table 4. 'Enabling' factors for change based on ~15 ‘coded’ interviews

Discussion

As demonstrated, the nature of innovation in the UK fresh produce industry is complex. Through interviewing a range of industry experts, we have begun to provide answers for several of the project’s research questions (see Appendix), as well as to start to contribute to an Agricultural Innovation Systems analysis of the sector.

The nature of the industry itself seems to determine innovation outcomes; the pressure of the marketplace, coupled with an entrepreneurialism, which other sectors of farming are accused of lacking, drives innovation. As such, innovation is seen to be ubiquitous, occurring across the value chain. A few notable sources of innovation are emerging from the data, however, with research institutes(both here and overseas), certain private businesses and producer organisations (based in the UK and elsewhere) and even smaller growers playing a part. Further work will clarify how these innovators operate in the innovation landscape of the UK fresh produce industry.

In addition, there are a number of personal barriers to innovation, often those previously identified in extension science literature, and institutional barriers to innovation that, in the case of the fresh produce industry, result in unique challenges.

One important descriptive coding category, *forms of communication, organisation and collaboration* being its working title, is yet to be interrogated in a meaningful manner, but should offer a detailed analysis of how the various actors that make up the fresh produce industry interact with regards to innovation.

Further Research

The transcription and analysis of interview data is expected to be finished by the end of Spring 2016. Following the completion of this stage of the research, a case study focussing on a specific innovation will begin, which should provide an opportunity to 'test' some of the observations made during the less specific interview stage of the research.

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.

Glossary

AIS (Agricultural Innovation System, sometimes including the word 'knowledge')	The system in which agricultural innovation takes place, consisting of a range of heterogeneous actors
Bounded (rationality)	Assumption that decision-making is limited by information, cognitive capacity and time
Deductive & inductive reasoning	Philosophical distinction between conclusions derived from a concordance of premises that are assumed to be true (deductive reasoning) and specific conclusions derived from a combination of

	different premises thought to be true *most* of the time (inductive reasoning)
Innovation/support networks	The linkages (co-)developed by organisations to better achieve their innovation agendas for mutual benefit
Institutional environment	The rules, norms and other governance mechanisms at work in a given system, shaped by both those who operate within that system and those without
Socio-technical system/regime	The co-evolving and interrelatedness of social and technical aspects of an organisation or society

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Appendix

1. Elzen *et al.* (2004) offer an adapted ‘innovation typology’, in which innovation can have four properties with regards to ‘technology’ and linkages with ‘users’:
    I. Architectural: disruptive of existing technology and linkages with users
    II. Niche creation: disruptive of linkages with users (exploring new markets), whilst preserving technology
    III. Incremental: conserves both existing users and technology
    IV. Revolutionary: disruptive of technology, whilst conserving user linkages

    It is not clear, at least rhetorically, whether Elzen *at al.* perceive “technology” as covering what we might call “non-technological” innovation – such as improved growing methods,

for example – or only the more narrow understanding of “technology” as a material invention.

2. The research questions framing the project are:
    I. How is the fresh produce research and development/knowledge transfer pipeline constructed?
    II. What are the key issues or problems relating to translation and exploitation of research within the supply chain?
    III. Are these problems specific to a particular part of the supply chain?
    IV. What methods of knowledge transfer/communication channels have been found to be the most effective?
    V. Are there good examples of effective translation and exploitation of research?
    VI. How do stakeholders go about communicating their needs to other parts of the supply chain?
    VII. What incentives exist/should exist for producers to take up new technologies or methods?
    VIII. What possible actions or recommendations would help address these issues?

    It was felt by the researcher that these questions did not give sufficient weight to the insights developed in the fields of extension science and agricultural systems approaches in recent years, namely the focus on interactivity, emphasis on the role played by private businesses, non-governmental bodies and farmers themselves, and the re-conceptualisation of research institutions in that system. As such, interview questions were designed to accommodate the demands of the initial research questions with observations from existing literature.

