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Rural Business Research

Farm Business Innovation, Cooperation and Performance




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independent research, data and analysis

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Acknowledgments

This study was made possible through the support provided by Defra who fund the Farm Business Survey (FBS) in England. Thanks are given to the FBS Co-operators who willingly gave of their time to take part in this survey and to the Research Officers (ROs) from Rural Business Research (RBR) who undertook the interviews with FBS Co-operators. The views and comments expressed herein are those of the authors alone, where the responses of farmer respondents have been quoted, these have been clearly identified. Thanks are given to Defra for constructive comments on the draft version of this report.

Executive Summary

- Defra's strategic plan includes increasing the productivity of the agricultural sector within the context of sustainable intensification. This project aims to analyse the drivers and motivations of farmer cooperation and innovation practices.

- Previous literature shows that financial, efficiency and labour saving objectives are the main drivers for farm business cooperation and innovation. Typically, larger farm businesses, younger farmers, farmers with greater levels of education, farmers who are willing to take risks, farmers with access to own funds or credit, and farmers with greater networks and networking capacity are more likely to engage in innovative practices. Additionally, innovations that fit with current farming practices and where the innovation is 'pulled' or demanded from the farming sector, are more likely to be taken up by farmers.

- Previous research also cites financial, economies of scale, efficiency and labour saving factors as drivers of farm level cooperation; the presence of networks, discussion groups and innovation brokers in enabling cooperation has been previously identified as facilitating cooperation. Compatibility of machinery, technology or labour resources, coordination along a value chain, plus working practices where trust exists between parties, also facilitate cooperation.

- Drawing upon data from the Farm Business Survey (FBS) for 2011-2013 inclusive, farm businesses within the main agricultural farm types were classified as high, medium or low performing on the basis of agricultural output to agricultural input ratio.

- In order to explore the impact of farm and farmer characteristics on farm performance, analysis of data from the above sample of FBS farms for the 2012/13 year found that farm performance was not significantly different between farm size, farmer age or farmer educational level groups within farm types. Moreover, there was no significant difference in levels of cooperation by farmer age, education or farm tenure groups; additionally there was no significant difference between farm performance and levels of cooperation.

- The analysis of the FBS data for 2012/13 shows that there are no clear patterns that emerge between levels of cooperation and farm or farmer characteristics; overall, labour and / or machinery cooperation as defined in the FBS was identified on fewer than 20% of farm businesses. Incidences of contracting out or contracting in livestock rearing were typically found on 10-30% of livestock farms, when analysed by farm type groups. Because the FBS does not directly collect data on innovation uptake, it was not possible to directly test for differences between farm and farmer characteristics and innovation uptake from current FBS data.

- Exploration and analysis of the quantitative data demonstrates that qualitative approaches are necessary to provide an in-depth understanding of the key drivers of, and outcomes from, cooperation and the uptake of innovative practices.

- Results from in-depth case study interviews with 60 farmer respondents showed that arable respondents almost exclusively used an agronomist, while the use of feed specialist occurred on some livestock farms; less frequently cited was the use of business or other consultants when undertaking major projects.

- Four-fifths of farmer respondents interviewed reported some level of informal cooperation with just under one-half citing involvement in formal cooperation. Farming cooperation was cited as of greater importance on Dairy, Cereals and General Cropping farms. Machinery sharing, joint harvesting, lending out of breeding sires and straw for manure swops were all cited as key aspects. The

majority of case-study respondents used contractors for aspects that were either central to their business or for more minor activities.

- Cooperation was often driven by several factors which can be categorised as either "people" (the style of farmer and relationships with neighbours), "practical" (availability / need for labour or machinery), and "profit" (mutually beneficial financial opportunities). Barriers to cooperation included bad experiences in the past with machinery sharing, biosecurity concerns or specific local aspects, for example neighbours not sharing an interest in cooperation.

- Three-quarters of all respondents indicated a positive attitude towards innovation, with the majority categorised as cautiously positive towards innovation. Overall, respondents held a pragmatic approach to innovation. Key areas of innovation on the case study farms related to: changes in breeding, health care and feeding policy for animal enterprises; changes to cultivation, harvesting, crop husbandry techniques, including new varieties, and precision agriculture aspects for arable enterprises; and new machinery, plant or software and investment in green energy or energy saving activities across all farm types.

- Barriers to innovation included financial (lack of internal or external funds), expense (cost of innovation too large to be justified for farm or enterprise), risk aversion and respondent age / life cycle factors (e.g. nearing retirement).

- Key barriers to business development and growth included the high cost of land for either purchase or rent; on poor performing tenanted farms gaining access to credit was more challenging than for high performing owner occupied farms, with the latter group recognising the increased value of farm land that can provide a basis against which to borrow funds for business development (e.g. green energy).

- The incidence of recorded innovations in the previous three years was higher on lower and medium performing farms than on top performing farms. Examples of top performing farms not perceiving the need to innovate, and low performing farms recognising the need to innovate to improve performance, were both observed. These examples potentially reflect high performing farms that have previously innovated and are now accruing returns from previous investments, and also farms with a low cost base that flow from natural comparative advantages of the farm (e.g. soil type). The case-study findings highlight the challenges of categorising and capturing innovation with respect to time-scales and definitions.

- Farming press, workshops and technical events were common methods of keeping up to date with technical developments. Further sources of information included discussion groups and communication with other farmers (including on-line forums). More technical information was sourced from experts such as vets, agronomists, independent advisors and product suppliers.

- Attitudes towards training and qualifications were generally positive but more frequently cited in large farm businesses, with cost representing a barrier for smaller and medium sized businesses. Older respondents, or those approaching retirement, were less positive towards training needs.

- The most common strategy for machinery and equipment replacement was to replace 'when needed'. However, financial (e.g. grant) and tax incentives were noted to incentivise machinery and equipment replacement, with a number of respondents noting the need for additional training on new technology (e.g. GPS) in order to gain maximum benefit from this innovation. The use of contractors was observed as a method of obtaining contemporary machinery and technology that could not be justified on individual farm businesses.

- While profit maximisation was recognised as a key objective, this was also balanced against the need to maintain or improve the farm, and within most cases this was additionally and importantly also balanced against personal / lifestyle objectives. The presence of a successor was observed in some cases to positively influence innovation uptake. The majority of respondents were positive about the prospects for their individual business.

- A Research Officer (RO) workshop identified that attitudes towards both cooperation and innovation were largely personality dependent and that there was no link between farm performance and collaborative activities or uptake of innovation.

- The RO workshop also identified a number of key opportunities and challenges facing the industry at the time of the study. Key points included: increased difficulty in securing land for business expansion driven by increased demand for bioenergy, food, and increased cost of obtaining land; changes to policies and regulations creating business uncertainty and new challenges; opportunities provided by green energy projects; improved (at the time of study) output prices for a number of livestock products.

Recommendations for Policy, Advisors and Industry

- Advice and policies focused around cooperation and innovation should articulate financial, efficiency and labour saving advantages. Approaches to cooperation within the arable sector, which recognise local needs and utilise local networks to articulate policy messages, are likely to be the most effective.

- Advice to other farmers from farmer respondents about cooperation included the need for 'give and take', flexibility in cooperation, trust and formalising arrangements; advice in relation to innovation included the need to progress cautiously, undertake research and learn from others, in particular from other famers.

- The farming press, sector-specific events, specialised advisers, ICT, mobile technologies and social networks can be utilised to engage farmers and the wider industry. Targeting early adopters and events aligned with hosting on-farm demonstrations offer multiple benefits whereby farmers can obtain practical, contextual, localised information across a range of innovations and technologies within a limited timeframe.

- Advice and policies which recognise and incentivise joint machinery investment, together with guidance and simple protocols for on-going cost sharing between businesses would both incentivise innovation on smaller and medium size farm businesses, and lower barriers to ongoing cooperation; the role of contractors in enabling small and medium sized businesses to access new technologies should be recognised.

- Tax incentives, grants, or interest free loans for new plant and machinery purchases have a direct impact on uptake of new machinery and technologies, but could be aligned with conditional training to achieve maximum benefit; moreover reducing cost barriers of training courses will enhance innovation uptake, in particular for small or medium sized farm businesses.

- The qualitative case studies show that the current definition of cooperation with the FBS does not fully capture the full range of cooperation occurring in farm business, and also highlighted the complexities in understanding innovation from a farmer perspective. Future quantitative studies should clearly clarify particular types of cooperative activity and innovations in order to fully capture activities occurring on farm businesses and in particular those beyond 'agricultural production' activities.

1. Background

Against a background of environmental pressures, world population growth and increasing recognition of the need for sustainable intensification of agriculture, Defra's strategic business plan includes championing a thriving, competitive British food and farming sector and driving sustainable growth in the wider rural economy in support of rural communities. Enhancing farm competitiveness and resilience requires long term performance improvements that encompasses management decisions as well as a focus on improving input-output and resource use efficiency. This project examines links between farm business strategies towards innovation and cooperation and farm performance, including farmer attitudes to, and barriers preventing uptake of, innovative approaches and new technology. Moreover, the study will explore the extent of farm-level cooperation that exists across both informal and formal structures, to understand the drivers of, and barriers to, cooperation. Hence, the study specifically seeks insights from farmers to ascertain the factors influencing the motivations for, and barriers to, adopting innovative practices, new technology and cooperation. This project also seeks to provide key transferable policy and industry messages to enhance uptake of innovation and cooperation practices.

1.1 Literature Review

An in-depth review of the literature on farm business innovation and cooperation was undertaken and is presented in Appendix 1. The objective of the review was to identify the key factors driving innovation and cooperation in agriculture. Drawing upon the findings of the literature review, key aspects affecting innovation and cooperation have been summarised below.

Table 1 shows factors influencing innovation. It shows that innovation is more likely to occur where it has a clear financial benefit or promises cost effective changes to a business, particularly via labour reducing approaches. Moreover, where the farm business has access to external or internal funds, access to advisers, training or information, and where the operator of the farm business has a greater level of educational attainment, uptake of innovation is more likely to occur. The above factors are frequently cited in the literature and hence are associated with a 'strong' degree of confidence.

Other factors that are associated with innovation uptake include larger farm or business size, younger farmers, farmers who are willing to take risks and those with access to farmer and social networks, or information communications technology (ICT). Moreover, the degree to which an innovation fits or aligns with current practice, and innovations that are defined as 'pull' factors from the industry, are also innovation-enabling. The above factors occur less frequently in the literature than those to which we have assigned a strong level of confidence, and have therefore been characterised as associated with a 'moderate' degree of confidence. Other aspects affecting innovation include farm tenure and the intensity of agricultural production. These factors have typically been cited as being enabling factors of innovation in some of the literature, but represent areas where other literature did not find any positive association towards innovation uptake and these have hence been associated with a 'weak' level of confidence.

Table 1: Aspects of Innovation

Innovation Enabling	Innovation Constraining	Level of confidence
Demonstrable financial benefit, particularly with respect to increasing revenue	Uncertainty over cost-benefit of innovation	+++
Access to credit or availability of internal funds	Internal or external funding constraints	+++
Greater educational attainment of farmer	Low level of education or training	+++
Cost effectiveness of innovation and labour reducing practices to achieve lower costs of production		+++
Training and access to advisers or information		+++
Larger farm / business size	Smaller farm / business size	++
Risk taking preference / ability to take risk	Risk aversion	++
Younger farmers	Older farmers	++
Level of "fit" or "usefulness" with current practices	Unproven technology or high level of adaptation required to current system	++
Innovation or technology "pull" from farmers	Innovation "push" from researchers	++
Farmer and social networks favouring innovation and peer group support; being new to an agricultural area	Historical approaches to farming; embedded inter-generational thinking	++
Information Communication Technology (access to)	Information constraints	++
Owned farm	Tenanted farm	+
Intensity of agricultural production		+

Key to level of confidence: + weak; ++ moderate; +++ strong

Table 2 presents a summary of the key findings in relation to cooperation. Aspects of cooperation that provide demonstrable financial benefits, economies of scale or efficiency improvements, for example via labour and machinery pooling, are more frequently cited in the literature as cooperation enabling drivers. Moreover, where farmers are involved in discussion groups, or have strong social cohesion networks within a local area, these have also been identified as positive drivers of cooperation. The presence of advisers and 'innovation brokers', greater compatibility of labour and machinery technology between parties, and the presence of interactions along the marketing or value chain, have also been identified as positive associative factors towards cooperation. Conversely, limitations in institutional support have been noted to be a constraining factor towards cooperation. Group cohesion and management have also been cited in the literature, with inaugural members of a cooperative group having wider motivational drivers than those joining a group later, with group laggards typically seeking to achieve financial benefit as the sole or primary reason for their cooperation. Additionally, the need for clear leadership and decision making has been cited as a cooperation enabling factor.

Table 2: Aspects of Cooperation

Cooperation Enabling	Cooperation Constraining	Level of confidence
Clear financial benefit / economies of scales / increase efficiency of production	No demonstrable financial or other benefit	+++
Labour and machinery pooling		+++
Farmer discussion groups / social cohesion	Social gaps between farmers	+++
Trust between farmers	Uncertainty over motivations of others	++
	Limitations in institutional support / infrastructure	++
Compatibility of labour, machinery or technology to sharing between members	Timeliness constraints shared resources	++
Advisers and innovation brokers	Lack of external influence on the group	++
Value or marketing chain interactions	Arms-length trading	++
Inaugural members of cooperation group	Joining established group / motivations for cooperation non-aligned with those of existing members.	+
Dedication of members with clear leadership / decision making processes		+

Key to level of confidence: + weak; ++ moderate; +++ strong

1.2 Aims and Objectives

The aim of this project was to identify farmer attitudes and current practice towards the uptake of innovative practices and technology, their level of cooperation with other farmers and the underlying reasons for this. The findings from the research will allow conclusions to be made regarding the identification of possible links between the uptake of these practices and economic performance. The key objectives of the research included:

1. Identification of the key drivers (and barriers) behind the adoption of innovative practices (including but not exclusively new technology).
2. Identifying the key motivators for farmers to cooperate with other farmers and the main barriers preventing this.
3. Establishing if varying farm business strategies for innovation and cooperation impact on farm performance both economically and physically.

2 Methodology

2.1 Sample Selection

Data was taken for three FBS years of 2010/11, 11/12 and 12/13. Within each farm type group, farm business performance was identified on the basis of agricultural output to agricultural input ratio, and for each year individual farm businesses were classified as low, medium and high performing. Using these individual year results, farm businesses were classified as low, medium or high performing if the business was classified as either low, medium or high in at least two out of the three years analysed. Where farm businesses did not meet the criteria for classification as low, medium or high performing these were excluded from consideration. The sample requirement across seven farm type groups is shown in Table 3:

Table 3: Sample Matrix for Case Study Farms

Farm type	Performance band		
	Top	Middle	Low
Cereals	4	4	4
General Cropping	2	2	2
Pigs	2	2	2
Poultry	2	2	2
Dairy	5	5	5
LFA Grazing	3	2	2
Lowland Grazing	2	3	3
Total	20	20	20

Farm businesses were selected from within the same region and wherever possible had similar key characteristics (e.g. farm or enterprise size). In some cases, farms were deemed not to be suitable for inclusion in the study because they had unusual features or business circumstance. Once farms were selected, they received a letter inviting them to participate in the study (Appendix 2). In some cases the RO who normally visited that farm business telephoned to seek their cooperation and briefly explain the basis of the survey. Only five farms contacted refused to participate, primarily because of particular circumstances at the time of contact. The distribution of completed returns matched the target distribution shown in Table 3. In nearly all cases respondents were not told which performance band they were in, except in a relatively few cases where it was mentioned during the course of the interview (primarily the top performers).

2.2 Analysis of FBS Data

Drawing upon FBS data for 2012/13, data was extracted for farm type, the percentage of utilised agricultural area that was owned, return on tenants capital employed (ROTCE[1]), farmer age, level of education, incidence of labour and machinery sharing and incidence of any form of contract rearing of livestock. These data were then analysed by farm type and performance group to test the hypothesis that there was no association between these variables and farm type and / or performance group. For normally distributed continuous data (for example data on farmer age) an ANOVA test was undertaken. For non-continuous or categorical data (for example farm type groups) a Chi-Squared test was undertaken[2].

[1] ROTCE was calculated as Management and Investment Income (MII) divided by Tenant's Type Capital. MII is the financial return to the farm business accounting for all revenue minus costs, where costs include the value of owned land (rental equivalent) and value of unpaid labour of the farmer, spouse and other unpaid labour.

[2] A continuous variable can take any value- for example farm income, whereas categorical data can only take a finite number of values, for example farm type.

The FBS data for 2012/13 was analysed in order to explore the impact of farm and farmer characteristics on farm performance and additionally the relationship between farm and farmer characteristics and levels of cooperation. This analysis was undertaken to establish if the presence or absence of particular farm or farmer characteristics may explain either difference in farm performance or levels of cooperation, and as such allow the study to place the qualitative results that explore cooperation and innovation in relation to farm performance, in greater context. For example if younger farmers achieve greater levels of performance it is instructive to examine if this finding relates to their level of education, the farm type they operate, or the level of cooperation they undertake. Conversely, if no association is observed between farm performance or cooperation levels and farm / farmer characteristics, this would lead to the conclusion that performance and cooperation are independent of farm / farmer characteristics. Because the FBS does not directly capture data on innovation, it was not possible to directly undertaken quantitative analysis with respect to levels of innovation. While other researchers have used investment as a proxy for innovation, this has also been recognised as a limited proxy variable because the direction of causality between innovation and performance is not clear; there is the potential for innovation to lead to improved performance, which in turn leads to investment, or *vice versa* (Renwick et al., 2014).

2.3 Semi-Structured In-Depth Interviews

Face-to-face interviews were undertaken in a semi-structured format (Appendix 3) to allow discussion of individual farm level decision making. Two experienced ROs from each of the six Rural Business Research (RBR) units carried out the interviews. The number of researchers involved was restricted in order to ensure consistency and robust interpretation. All researchers attended a full briefing meeting at the outset and a workshop at the completion of the fieldwork. It was agreed that researchers would not visit the farms they normally visited so that they did not have any pre-conceived bias relating to the holding or respondent.

The semi-structured interview consisted of four parts:

1. Background and management structure - exploration of the decision making process, use of external consultants, respondent's age and period of time farming at current location.
2. Farm Business Cooperation – exploring attitudes to cooperation and the extent to which the business entered into arrangements with other farms, whether on a formal or informal basis. Participation in joint venture arrangements, local networks and other factors that may explain variations in terms of business performance. Specific questions on contracting were also included in this section.
3. Innovation and Technology – exploring attitudes towards innovation and new technology, barriers to adoption of new technology, ways of keeping up-to-date and the use of professional advisors. The definition of innovation[3] drew upon the OECD definition. Following the training meeting, ROs had a clear view of what innovation entailed so that they could put it into their own words to aid respondent understanding of the OECD definition. Innovation could be new to the business but

[3] Innovation can be changes in the product(s) or the way they are produced through, for example, new machinery or 'organisational' innovation such as business practices (e.g. benchmarking) or the way the business is organised (e.g. internal or external business relationships including marketing). An innovation must contain an element of novelty, but this can be new to the farm or new to the market/world. It can consist of the implementation of a single significant change (e.g. a new business arrangement) or of a series of smaller incremental changes that together constitute a significant change e.g. gradual adoption of precision farming techniques.

widespread to the industry or new to the industry (e.g. cutting-edge practice not adopted more widely).

4. Goals and Objectives – the perspectives of those running the farm business were explored including succession of the farm business.

The interviews were structured so that open questions were asked prior to any prompting of respondents, in order to gain the respondent's understanding of the relevant questions. ROs recorded answers given to each successive question even if contradictions occurred between answers. All interviews took place between the beginning of February and the middle of March 2014. The average length of interview was 83 minutes with a range from 45 to 120 minutes. Intensive livestock farm interviews were typically the shortest with LFA grazing farms the longest. Interviews tended to be longer for the lower performing farms compared to the other two categories. Interview qualitative data were transcribed from detailed interview notes, including quotes from respondents, into a structured word document by the RO immediately following each interview. Thematic analysis of the collated interviews was then undertaken to identify recurring themes, key words, phrases or approaches.

2.4 Research Officer Workshop

A workshop for ROs was held on the 1st April 2014 which sought to explore issues of cooperation and innovation that arose from undertaking the case study interviews and to gain wider understanding of innovation and cooperation in agriculture more generally. Moreover, opportunities and challenges facing the agricultural industry were explored in the workshop to provide wider context to the contemporary issues surrounding the case study.

3 Results

3.1 Quantitative Analysis (2012/13 data)

Drawing upon existing FBS returns, data was extracted for a range of observed measures in order to test the hypothesis that farm performance is independent of a range of farm and farmer characteristics, including the level of cooperation. Moreover, the data was used to test the hypothesis that cooperation is independent of farm and farmer characteristics. The data utilised included farm type, the percentage of utilised agricultural area that was owned, return on tenants capital employed (ROTCE), farmer age, level of education, incidence of labour and machinery sharing and incidence of any form of contract rearing of livestock. As noted in section 2.2 these tests were undertaken to establish the presence or absence of structural factors affecting farm performance or levels of cooperation in order to place the qualitative results in context.

3.1.1 Tenure and Return on Tenant's Capital Employed

Farm performance (as defined for this study based on the ratio of agricultural output to input) was analysed with respect to tenure and ROTCE, accounting for farm types to test the hypothesis that there was no association between farm performance, farm types, tenure and ROTCE. A Chi-Squared test on the proportion of predominantly land-based farms with more / less than 50% of the utilised agricultural area owned indicated no significant difference by farm type and performance group ($p=0.385$) (Figure 1a), and hence it can be concluded that overall, farm type is independent of the performance group as defined for this study. This result means that while farm type may have some influence on farm performance, a range of other factors are also likely to explain the variation in performance, beyond farm type, potentially including levels of cooperation and innovation. However, with respect to analysis of ROTCE for the farm business (in contrast to the ratio of agricultural output to agricultural input that defines farm performance in this study), an ANOVA test on the continuous (normally distributed) data indicated a significant difference in ROTCE (for the farm business) by farm type ($p<0.001$), performance group ($p<0.001$) and the interaction between farm type and performance group ($p<0.001$) (Figure 1b). Hence, when examining the potential influence of cooperation and / or innovation with respect to performance from the qualitative analysis it is in instructive to remember that key drivers of ROTCE include farm type, albeit that no significant relationship between *farm performance group* and farm type was identified. However, the significant relationship between farm performance and ROTCE indicates that the performance bands used in this study are, on average, also suitable proxies for overall farm business performance, in addition to providing metrics of agricultural performance. Hence, the *agricultural* farm performance bands used in this study are argued to additionally represent *farm business* performance bands. Hence, any findings that emerge for the farm performance bands are argued to therefore hold at the business level as well as the agricultural costs centre level.

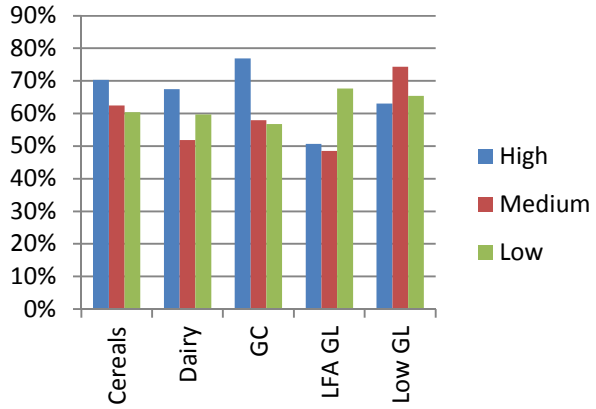

Figure 1a: Percentage of farms with >50% of Utilised Agricultural Area owned by Farm Type and Performance Group. Key: GC=General Cropping; LFA GL=LFA Grazing Livestock; Low GL=Lowland Grazing Livestock.

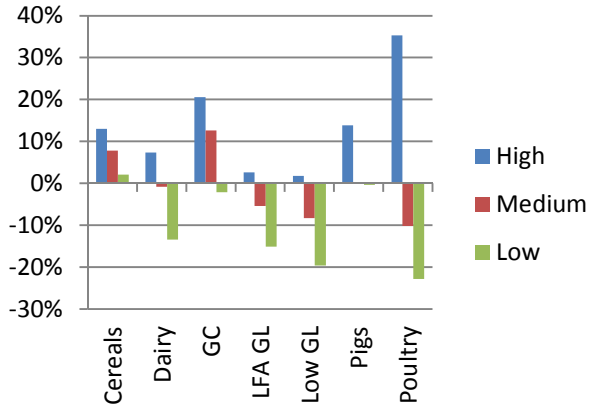

Figure 1b: Return on Tenants Capital Employed (ROTCE) by Farm Type and Performance Group. Key: GC=General Cropping; LFA GL=LFA Grazing Livestock; Low GL =Lowland Grazing Livestock.

Figure 1: Farm Land Ownership (1a) and Return on Tenant Capital Employed (1b) by Farm Type and Performance Group.

3.1.2 Biographical Analysis

In order to explore the possibility that farmer age and education levels may be linked to farm type groups and performance bands, data on farmer age and education levels were analysed. Data on farmer age (normally distributed) was analysed by ANOVA. Dairy, Pig and Poultry farmers are slightly younger than farmers in other farm types; a significant difference ($p<0.001$) in farmer age by farm type was identified. However there are no significant differences in farmer age by performance group ($p=0.195$) and also no significant interaction effect between age and farm type group ($p=0.372$) exist. The percentage of farmers with further or higher education by farm type and performance group (Figure 2b) demonstrates no significant difference of education levels by performance group and farm type ($p=0.612$), albeit that further and higher education is generally lower on LFA and Lowland grazing livestock farms. Hence, it is worthy to note from these results that there is a link between farmer age and farm type. It will be instructive to consider this result when examining any differences between farmer age or farm type and cooperation or innovation that emerge from the qualitative analysis.

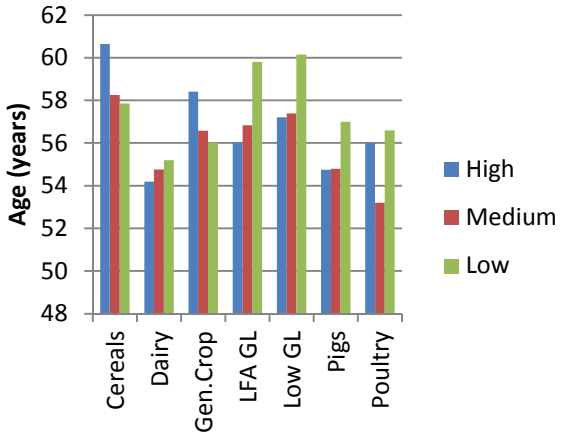

Figure 2a: Farmer Age by Farm Type and Performance Group. Key: GC=General Cropping; LFA GL= LFA Grazing Livestock; Low GL = Lowland Grazing Livestock.

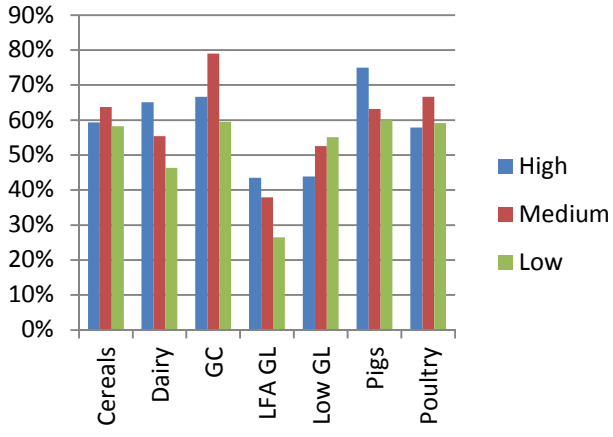

Figure 2b: Percentage of Farmers with Further or Higher Education by Farm Type and Performance Group. Key: GC=General Cropping; LFA GL= LFA Grazing Livestock; Low GL = Lowland Grazing Livestock.

Figure 2: Farmer Age (2a) and Education (2b) by Farm Type and Performance Group

3.1.3 Collaboration

The incidence of labour and / or machinery sharing as recorded in the FBS is shown in Figure 3a. No significant influence of farm type or performance group in relation to labour and machinery sharing was identified (p=0.595), however, it is informative to note the trend for General Cropping farms to cooperate more than other farm types in relation to labour and / or machinery sharing (Figure 3a). Moreover, across the farm types it is informative to note that labour and machinery sharing is, on average, observed on less than 20% of the sample. The incidence of contract rearing (all forms) of livestock (Figure 3b) amongst livestock farms, indicates that for Dairy and LFA Grazing Livestock farms, there appears to be a trend of lower contract rearing activity in the medium and lower performance bands. However, the reverse is observed for Pig farms. Overall, there is no significant difference (p=0.488) in contract rearing activity by farm type and performance group. The results in Figure 3b should be considered within the context of the definition of the farm performance groups. This definition is based upon the ratio of agricultural output to agricultural input. Those livestock farms that are contract rearing livestock for a third party will incur, in total, lower levels of both agricultural output and agricultural input relative to an identical sized unit that owns the livestock. For example, a unit with owned livestock that generates an output of £10,000 may incur input costs of £8,000, generating an output-input ratio of 10,000/8,000=1.25, with an absolute margin between output and input of £2,000. By contrast, a unit with contract owned livestock may generate revenue of £3,000, incurring input costs of £1,500 generating an output-input ratio of 3,000/1,500=2.0, with an absolute margin of £1,500. Hence, in respect to the output-input ratio used, the unit with contract owned livestock returns a greater output-input metric, but with a lower absolute margin between output and input, relative to the unit with owned livestock.

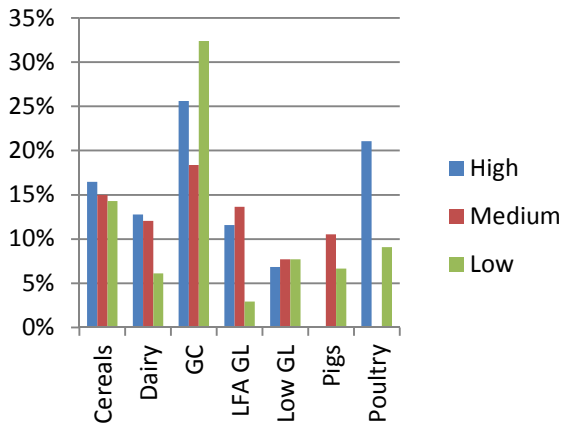

Figure 3a: Labour and / or Machinery Sharing by Farm Type and Performance Group. Key: GC=General Cropping; LFA GL=LFA Grazing Livestock; Low GL=Lowland Grazing Livestock.

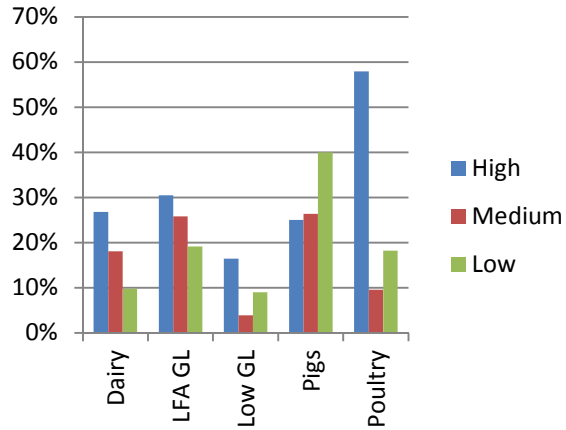

Figure 3b: Contract rearing (all forms) by Livestock Farm Type and Performance Group. Key: GC=General Cropping; LFA GL=LFA Grazing Livestock; Low GL=Lowland Grazing Livestock.

Figure 3: Labour and / or Machinery Sharing (3a) and Contract Rearing (3b) by Farm Type and Performance Group

Exploring levels of cooperation in contract rearing and labour and / or machinery sharing by farm and farmer characteristics, Figure 4 demonstrates variation across farmer age, education and farm tenure groups. However, there is no significant difference between levels of contract rearing and labour and / or machinery sharing by farmer age group (p=0.5041), farmer education (p=0.2686) and farm tenure (p=0.5389).

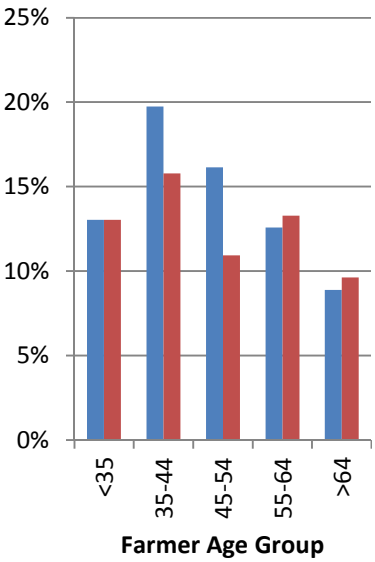

Figure 4a: Contract Rearing and Labour and / or Machinery Sharing by Farmer Age Groups Type.

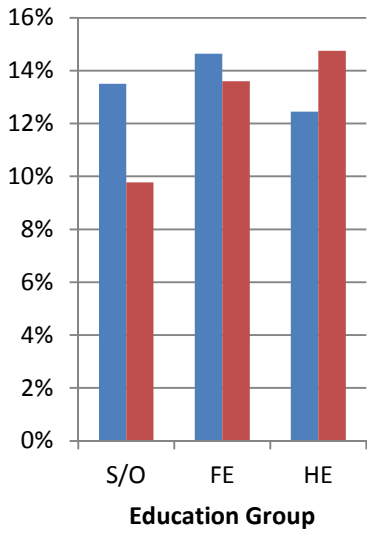

Figure 4b: Contract Rearing and Labour and / or Machinery Sharing by Farmer Education Group. Key. S/O=School/Other; FE=Further Education; HE= Higher Education

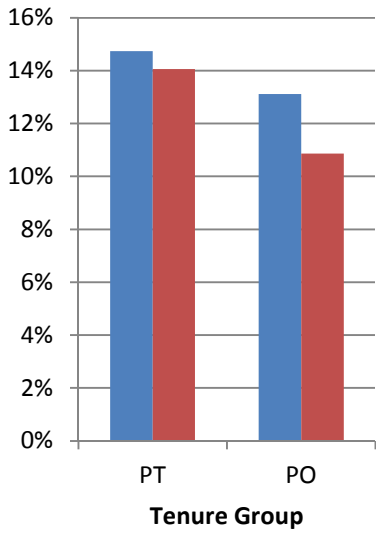

Figure 4c: Contract Rearing and Labour and / or Machinery Sharing by Farm Tenure Group. Key. PT=Predominately Tenanted; PO= Predominately Owned.

Figure 4: Contract Rearing and Labour and / or Machinery Sharing by Farmer Age (4a), Education (4b) and Tenure (4c).

3.2 Qualitative Analysis

3.2.1 Biographical Aspects

The average age for farmer respondents interviewed in this survey was 54 with a range from 29 to 73 years of age. This mean range is lower than the mean identified in 3.1 (for the 2012/13 FBS sample), however, given the modest sample size for the case studies, there is no evidence of bias in the sample towards younger respondents. Farmer respondents were, with one exception, male. However in most cases the interview was undertaken with the farmer respondent or the farming couple.

3.2.2 Decision Making and use of Consultants

The respondents were evenly split between those who regarded themselves as sole decision makers and those who did not. However, the distinction is not always clear cut; some of those citing they were the sole decision maker would also discuss aspects with other family members; the key factor in relation to being the 'sole' decision maker being that the final decision rested with the respondent. Around four-fifths of respondents indicated that they used consultants or advisors; however, there was a marked difference between advisor use by farm types. All the Cereals and General Cropping farms reported the use of consultants, compared to just two of the seven LFA Grazing farms. A key explanation for this was the almost universal use of agronomists on those farms with arable cropping. Additionally, some of the instances of consultancy use on dairy and intensive livestock farms related to agronomy advice rather than livestock specific consultation. Furthermore, many LFA farms reported no use of consultants, however, the interview highlighted that they sought help from an advisor when applying for environmental schemes for example. These issues highlight the difficulties in defining advisor or consultant in farm business management or agricultural production. For example, a farmer may heavily rely upon a vet, but not view this input as consultancy or

advice. There were some responses that indicated the respondents were very much opposed to the cost of advisors as the following quote makes clear.

> "*Only time we use an advisor is if we are doing something we are not totally sure about and even then we tend to use quotes from builder or look into it, we wouldn't get a land agent round to do this, that and the other, as a lot of the time they are no better than you are and they just charge you for it*".

3.2.3 Farm Business Cooperation

3.2.3.1 Cooperation with Other Farmers

ROs were provided with guidance on types of informal and formal cooperation, but there is no universally accepted definition available. Respondents often made the distinction between informal and formal arrangements according to exchange of money. For instance, on intensive livestock farms the swopping of manure for straw was common and this was classed as informal. However, the use of money as a defining characteristic does not always apply; several respondents reported the fact that they bought feed from neighbouring farmers as examples of informal cooperation, yet with financial exchange occurring. The majority of respondents indicated that they cooperated in some way with other farmers. Four-fifths of farmers in the sample reported some level of informal cooperation whilst just under one-half reported involvement in formal cooperation. With only one exception, where formal cooperation existed, informal cooperation was also found. Arable farms were more likely to report cooperation than livestock farms, in part reflecting the nature of the different sectors, whereby arable production is characterised by comparatively lower labour input systems than the livestock sector, creating a greater incentive to cooperate in order to achieve low labour costs and remain cost-competitive. Some respondents could be described as 'multi-cooperative'; one dairy respondent contracted out the replacement of his dairy heifers, he utilised his neighbour's poultry manure because his neighbour was at the limit of Nitrate Vulnerable Zone (NVZ) restrictions and he used a third neighbour as a contract grower for his maize crop.

Most common examples of cooperation included machinery sharing, contracting operations, splitting of harvesting operations such as hay, silage or corn harvesting, lending out of breeding sires and straw for manure swops. Less frequently mentioned would be marketing arrangements, such as those for intensive livestock or milk (e.g. members of SCOTLEAN, ARLA), share or contract farming, or membership of a buying group. Perceptions about contracting as a form of cooperation varied; some respondents perceived contract work as a type of cooperation, whilst others viewed this as a service. One respondent was adamant that providing contracting was a type of cooperation because of the need to work well with other businesses to attract and retain their custom. He also indicated that as a contractor he provided an advice service to his customers. One respondent, who noted that they did not cooperate, went on to indicate that he does not contract for anyone else 'unless helping them out', indicating a form of irregular cooperation. Levels of cooperation or interaction were found to change over the life cycle of a business. Some respondents noted the need to cooperate when starting their business, but as their business grew, their need to cooperate decreased. Others noted being surrounded by large farms that did not see the need to cooperate. Hence, cooperation is observed to be influenced by a combination of motivations and drivers: attitudes, business stage and local circumstance.

3.2.3.2 Importance of Cooperation

For Dairy, Cereals and General Cropping farm types, cooperation was seen to be very important and often related to core business decisions. In the other four farming types (Pigs, Poultry, LFA Grazing and Lowland Grazing), only three respondents thought

cooperation was 'essential', each case citing specific business points (manure for straw; marketing group arrangement; short term keep for livestock). A number of respondents in these farm type groups thought that cooperation was positive because it provided flexibility; working with neighbours fitted in with their farming. However, for the majority of farms in these farm type groups, cooperation was of little or no significance. The reasons why respondents cooperated were predominantly business-related, particularly on Dairy, Cereals and General Cropping farms. The benefits of cost saving or timeliness of farming operations, efficiency or economies of scale, or the use of contractors enabling the respondent to concentrate on the 'core' business were all cited as important drivers of, and motivating factors for, cooperation (Table 4). Additionally, the social interaction that cooperation provided was noted by some respondents (Table 4), albeit that the initial motivating factors for cooperation were business driven.

Table 4: Attitudes towards Cooperation

Positive	Negative
"Do it" *"Being neighbourly".* *"Share silage making equipment with a 50% share in a self-propelled forage harvester and rake with a neighbouring beef farmer. We also pool the trailers and labour and work together"* "*have a good laugh together*" [positive about cooperation but recognition of] "*not winning all the time*"	*"It is not that I am adverse to it, it is just that it is not practical to my situation"* *"Smallish farm and have pride in doing our own work, I want to be a farmer rather than a manager and organiser of staff."* [in relation to past difficulties over sharing machinery] *"If that's cooperation, then it's not for me"* *'Time availability is a major limiting factor'.*

3.2.3.3 Barriers to Cooperation

A variety of reasons were cited as barriers to cooperation, albeit that some respondents noted that there were 'no barriers' to cooperation. On intensive livestock farms, concerns over bio-security were highlighted as a barrier. Across all farm types, timeliness of harvesting was noted as a barrier. However, a good example countering this concern was cooperation between a dairy and beef farmer, with the dairy farmer making silage earlier in the season to maximise crop quality, whereas the beef farmer was more focused on crop quantity which facilitated later silaging. For respondents who did not share machinery, motivating issues revolved around concerns over machinery availability, share of repair costs between parties and condition of machinery after the other party had used it. It was apparent that there were mixed views on the impact of farm size on the level of cooperation. Some respondents thought that those with large farms have no need to cooperate whilst others thought that those on smaller farms were more independently minded. Some respondents noted their neighbours not wanting to cooperate with them, whilst others recognised that it was themselves that did not want to cooperate because they were independently minded in their business and farming activities. One respondent noted they did not have time to cooperate. Finally, one respondent cited that rules and legislation were limiting the amount of cooperation. He gave an example relating to that of transporting plastic for recycling - in order to collect his neighbours' plastic, he understood he would need to possess a haulier's licence. Consequently, individual farmers are making more journeys than if they shared the transport between them.

3.2.3.4 Giving Advice on Cooperation

Most respondents seemed willing to give advice on the subject of cooperation even if they themselves did very little cooperation. The need for flexibility - to 'give and take', the need for 'formal arrangements' and issues of trust were frequently cited (Table 5). Interestingly, a number of respondents thought that it was good to formalise any arrangements even if they themselves did not have any such agreements. Some respondents thought it was more difficult to cooperate now than it was in the 1980s as there is now greater pressure over the timeliness of harvest, with a perception of greater weather variability leading to some individual farmers structuring their businesses so that they are in a position to harvest crops with their own machinery and labour resources under ideal weather conditions. Six respondents declined to give any advice on cooperation, reflecting that they were not actively engaged in any cooperative activity.

Table 5: Advice on Cooperation

Flexibility	*"Give and take - be happy to do so, not just prepared to. Have a good relationship and it needs to be with the right person".* *'You must make sure that you get on with them and have trust.'* *"You need to be flexible" "No good getting hung up on who uses a piece of kit more, whether one person has more land to use it on, or one person has had it for x amount of days, in the end it benefits both of you" "Be flexible and don't count".*
Level of formal agreement	*"Everything should be written down as you need a structure". You must know what is expected of you and more importantly…. what is expected of them".* *"It needs a formal agreement to make it fair for all parties. If that's off putting to anyone then it's not worth doing. Better a formal agreement than a gentlemen's agreement, if they can't do formal then there must be a reason why."*
Trust	*"Only cooperate if it benefits you, or the other business, and make sure you trust who you are cooperating with. That's the biggest one".* *'Trust - if you do not trust someone then do not start'*

3.2.3.5 Incidence of Contracting Operations

For some respondents, the use of contractors, or the supply of contracting services, was seen as a type of cooperative activity and for others this was viewed as a service; overall nearly all respondents reported using contractors. For some, this was core to their business (e.g. dairy farmers using contractors for silage making; arable farmers using contractors for cultivation and spraying work; use of contractors for manure disposal). However, on many farms the use of contractors was for specific 'other' activities such as hedge cutting, ditch cleaning or pest (mole and rabbits) control. Where respondents provided contracting services this was generally only of an informal or ad hoc nature that was not core to the farm business. However, on a small number of farms, providing a contract service was very much an enterprise in its own right and was seen as a key part of the business. Examples include fodder beet harvesting, cultivation services, or informal but key arrangements, such as one farmer providing the baling and the other the wrapping for silage making; the latter example is not an isolated occurrence, but serves to reinforce the breadth and complexity of cooperation that exists.

3.2.4 Innovation and technology

3.2.4.1 Attitudes towards Innovation

Having been briefed with an understanding of what innovation might mean, respondents were asked to indicate their attitudes towards innovation. Despite the difficulties of classifying open ended questions, approximately three-quarters of respondents reported a very positive attitude towards innovation (Table 6). Some respondents were clearly enthusiastic about new things, whilst for the majority attitudes towards innovation reflected a pragmatic approach to business survival; this was partly identified by one respondent as a technology / innovation treadmill (Table 6). A positive attitude towards innovation was found across all farm types and all performance bands. A small cohort of respondents' attitudes towards innovation was very cautious. In some instances a positive answer towards innovation was followed by more cautious comments, indicating a desire to observe an innovation working on other farms before adopting it. These respondents occasionally note themselves to be traditionally minded or not risk takers; these were spread across the farm performance bands. Finally, there were some respondents who described themselves as opposed to innovation. In some cases it might be that they had not had the wherewithal to make change. Issues of age (nearing retirement), financial influences (lack of profit in the sector hindering adoption of new technologies), expense of new technologies, and innovations leading to a loss of skills were occasionally mentioned, for example the increase in minimum cultivation leading to loss of skills in ploughing. However, the overall response to innovation can be summarised as very positive.

Table 6: Attitudes towards Innovation

Positive	Negative or cautions
"Any new idea is positive, if it is a good idea now it's a good idea in five years' time. You've got to move forward or else you are doomed." *"If you don't embrace innovation, your business will go backwards."* *"Nothing against innovation, one has to keep up to date, particularly young people. There's always new things. Innovation makes you run to stand still, but you have to keep up to date. If you don't keep up to date a big decision will have to be made and might be prohibitively expensive - the day of reckoning."* *"I love new things! Anything that makes life quicker and easier..... I'm up for".*	*"Prefers things to be mainstream first".* *"I am 63 and running down to retirement. At 65 I will give up the dairy cows and go into suckler beef."* *"We all need to innovate to survive. I do not agree in innovation and new technology just for the sake of being up to date. I need to know that it will be an improvement on what I currently do and give me proven benefits. I work for myself and my family and so I am prepared to fit work in when it needs doing - time saving technology doesn't always seem worth the extra cost to me."*

3.2.4.2 What Should be done differently in the Farm Business?

When respondents were asked if there was anything that should be done differently in the farm business, three-quarters indicated that there was. There were a wide range of factors identified including changing the scale of enterprises, adopting specific technologies such as robotic milking or GPS for arable work, changing breeding policies, investing in more buildings and more staff training. The most common rider to these suggestions was that the technology was too expensive for their size of enterprise or holding. The majority of respondents were thinking pro-actively about what type of changes they would like to make about their farming operations. Those farms who did not feel they should be doing anything differently were typically happy with their current farming system and what they were doing. Some were dismissive of the question, suggesting that if there were changes to be made that would be of benefit to them, they

would already have made them; as one respondent noted - *"If there was something to save money I would do it"*

3.2.4.3 Adoption of Innovation Practices

In addition to asking questions about their attitude towards innovation, respondents were also asked to give examples of innovative practices that they had adopted in the last three years. Innovation was defined as either new to the industry, or new to the respondent's business, but not necessarily new to the industry. Furthermore, the innovation may have been a number of small incremental changes to processes rather than the adoption of new technology *per se*. The number of innovations cited by farm type and performance groups is shown in the Table 7. The numbers of innovations recorded indicate that innovative practices are occurring across all farm types and all performance bands. Indeed, the lower performing farms on average reported more innovative practices per farm than the top performing farms.

Table 7: Adoption of Innovation in last Three Years

	Category	Number of innovations recorded
Farm Type	Cereals	18
	General cropping	18
	Pigs	18
	Poultry	8
	Dairy	41
	LFA Grazing	17
	Lowland grazing	21
Performance Group	Top	41
	Middle	49
	Low	51
	All	*141*

Only two respondents noted that they had undertaken no innovations; these were both in the top performing group (one poultry and one general cropping farm). The general cropping farm respondent noted that not adopting any innovative practices had been part of his business strategy, describing the farm as *'traditional and not technical'* and his self-perception *'I am not particularly technically minded'.* Conversely there were two farms recording seven innovations each and these were both low performers (one dairy farm and one general cropping farm). The dairy farm respondent had undertaken seven 'major' different innovations; he noted he was looking to continue to introduce new practices even though he planned to retire in the next three years. He thought that '*innovation makes you run to stand still'* but that if you did not innovate you would fall behind.

3.2.4.4 Giving Advice on Innovation

All but three of the respondents were happy to give advice on the issue of adopting innovative practices. The advice covered a range of attitudes categorised along a positive/cautious response continuum. However, the number of responses expressing caution outweighed those advocating a proactive approach. Even those most enthusiastic about adopting innovation emphasised the need for caution when they were asked for advice for others. Some of the advice was of a practical nature relating to finance or other aspects such as visiting other farms. A common theme of many responses was that of making sure the innovation was right for the farm in question and the need to undertake research (Table 8).

Table 8: Advice on Innovation

Positive	Negative or cautions	Practical considerations
"Have to move with the times and go for it. Get the basics right then go forward". *"Make use of modern technology, don't stick in the past"* *"If you are not continually looking to improve something then something is wrong - if you look hard enough you can always identify something that needs attention"* *"If it's of benefit to the business you should at least look at it as shouldn't stand still."*	*"Let somebody else do it first. Do not be scared to use it. Make sure it is worth it in terms of finance and time. Do your research".* *"Be very cautious, especially if it involves lots of money"* *"Tread cautiously"* *"Be careful, do not take on too much risk. Fools rush in where angels fear to tread. If it is a good idea, it does not need advertising".* *"Be careful. Bigger is not necessarily better."*	*'It also depends on how adverse an individual is to risk…..You must do your homework first as certain practices could end up being an expensive mistake; however on the other hand you should be happy to give things a go.'* *"Go and look at things on other farms first - go on farm visits, ask farmers, ring professionals, and make sure you are certain that the technology is right for your own farm"*

3.2.4.5 Keeping up to date with Technical Developments

With respect to keeping up to date with technical developments for both themselves and for staff working on the farm, the two most common responses were use of the farming press and attending workshops or events. Technical information was also sourced from vets, agronomists, independent advisers and product suppliers. A number of respondents stated that they use agronomist advice provided alongside a product supplied, and which is therefore not paid for separately. Conversely, other respondents stated a reluctance to take some information on new ideas or products from those with a vested interest, such as those also selling products. The incidence of communication between farmers themselves was relatively common in relation to technical development, and was cited as one of the most important sources of information for decisions by farmers: *"…a lot to be learnt from well performing farms".* Online information was reported to be accessed by just under one-third of those surveyed and this source of information was utilised more by the 'medium performers'. The relatively high incidence of discussion groups and communication with other farmers suggests that farmers are keen to learn from others as much as from written material. Two-thirds of respondents surveyed were involved in some kind of discussion group or similar; there was a higher incidence of this information source amongst Poultry and General Cropping farm types. Respondents not involved in groups at all were more frequently associated with the low or medium performance bands. Specialist Pig and Dairy farms more frequently utilised a *variety* of technical resources; by contrast lower usage was recorded for respondents in the Cereal and LFA Grazing farm types. Accountants were frequently quoted as a source of advice, with respect to financial aspects directly and also strategic opportunities (e.g. diversification, grants), mentioned by over one-third of respondents.

3.2.4.6 Approach to Training and Qualifications

Three quarters of the respondents provided a positive or proactive response to the need for training and qualifications, however one-quarter were either uninterested or negative towards training. Typically those less interested were coming towards the end of their farming careers or bought in the necessary expertise through their advisors; some older respondents recognised the need for younger family members or their staff to attend training courses. One respondent who could be classed as negative towards training had been refused farm assurance status for his livestock because he had no formal qualifications, and he was not prepared to write a letter outlining his own practical experience. In another case, the respondent would like to do more towards training but

could not afford the labour being away from the unit. Some respondents cited that a lot of technical courses were not relevant to their particular farming operations.

Larger farms often had formal training programmes in place and it was the smaller, one-person, operations where there was least involvement in training. One large General Cropping farm ensured that all staff had an annual appraisal and that they were placed on a structured continuing professional development programme. This ensured that the skills and qualifications of the staff matched the needs of the business. However, some were concerned about the cost, one respondent stated: *"It would have to be a bloody good course before I spent any money on it, I must admit."* Yet the opposite view was just as prevalent. One respondent who used an agronomist, was himself fully BASIS and FACTS qualified so that he could evaluate the recommendations from the agronomist: *"It's a bit like taking your car to the garage by knowing what they are talking about you won't get fleeced."*

3.2.4.7 Business Strategy for Machinery and Equipment

The most common reported strategy for investment in machinery and equipment was replacement of the item 'when needed'. Over one half reported that they would make an investment when they needed to because the machine was no longer fit for purpose or because a new investment would make life easier. Hence, the decision to invest was driven by particular machine circumstance, such as costly repairs, or that the money was available for investment, rather than driven by an investment strategy *per se.* One exception to this was the strategy reported on a small number of farms of replacing machinery when the warranty had expired in order to reduce their exposure to large repair bills. Purchasing of second-hand equipment was frequently quoted as their business strategy for machinery, leading to lower depreciation costs, but generally associated with lower warranty levels and potentially greater maintenance costs than new machinery. Two other key aspects cited were the importance of good machinery maintenance strategies and appropriate use of contractors. Most respondents' recognised maintenance and repair costs, need for improvement or updating, finance and tax issues as drivers for machinery investment:

> *"…Like to buy 1 to 2 pieces of machinery a year, to keep machinery up to date, to make life easier and to take advantage of capital expenditure tax relief."*

Just under one-half of the sample reported making changes by adopting different types of machinery in the last three years. This was true for most farm types with little discernable difference between the performance bands. Examples of investment included Global Positioning Systems (GPS), aerators, new drilling techniques, including minimum cultivation, and larger machinery. In a number of cases the adoption coincided with increased use of contractors because only the contractor could provide the necessary equipment or they thought they could not justify it on their own farm. Of the examples cited, GPS and minimum cultivation were the two most cited investments; conversely some respondents felt they had to explain why they had *not* adopted minimum cultivation or GPS. This latter issue illustrates how these items have come to be identified as examples of innovation in the agricultural community.

3.2.5 Classification of Innovations

From the responses provided, it is possible to classify the innovations that have taken place on the case study farms. From the 60 case-study respondents, a total of 156 'innovations' were recorded (Figure 5). With respect to livestock (Figure 5a), the key innovations were: changes in healthcare policy / breeding techniques; changes in feed policy such as diet, method or timing and; changes in breeding *per se*. For arable enterprises (Figure 5b), key innovations were: changes to cultivation or harvesting techniques; new crops, varieties or rotations; changes to fertiliser policy or techniques

and; soil / yield / disease sampling / mapping. Across enterprises types (Figure 5c), the largest number of innovations was observed for new machinery, equipment or software, followed by new buildings and fixed capital, then green energy or energy saving. Other innovations cited included changing marketing outlet, ceasing an activity, diversification and increased farm visits or use of social media.

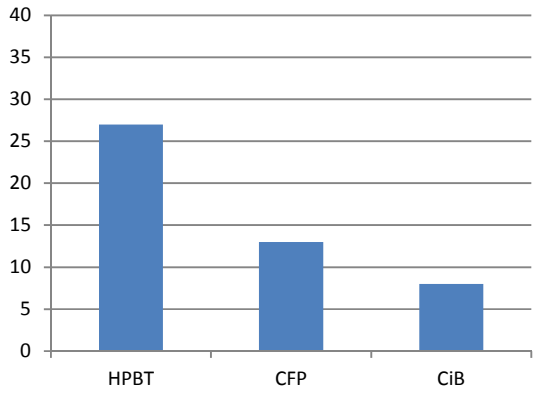

Figure 5a: Livestock Specific Innovations. Number of farm businesses reporting an innovation within the innovation group within the previous three years.

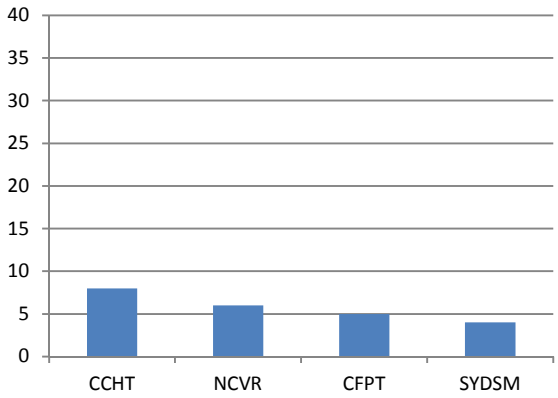

Figure 5b: Arable Specific Innovations. Number of farm businesses reporting an innovation within the innovation group within the previous three years.

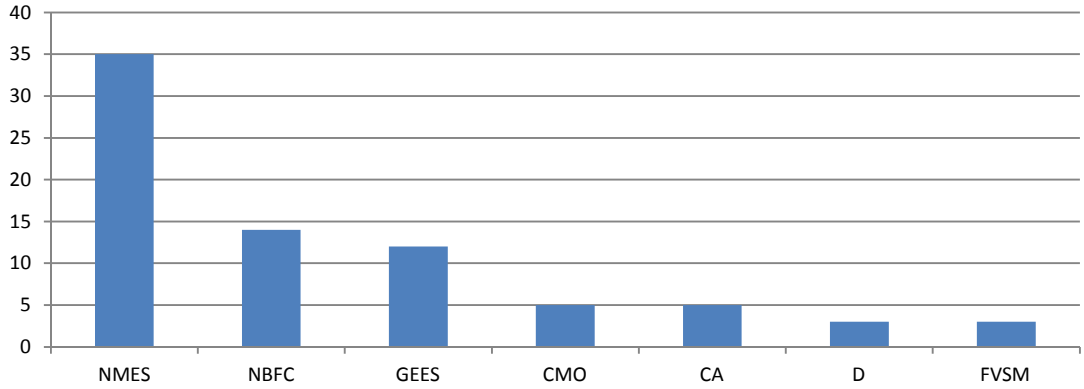

Figure 5c: Non Sector Specific Innovations. Number of farm businesses reporting an innovation within the innovation group within the previous three years.

Key: HPBT=changes in healthcare policy / breeding techniques; CFP=changes in feed policy such as diet, method or timing; CiB= changes in breeding *per se*; CCHT= changes to cultivation or harvesting techniques; NCVR=new crops, varieties or rotations; CFPT=changes to fertiliser policy or techniques; SYDSM=soil / yield / disease sampling / mapping; NMES=new machinery, equipment or software; NBFC=new buildings and fixed capital; GEES=green energy or energy saving; CMO=changing marketing outlet; CA=ceasing an activity; D=diversification; FVSM=increased farm visits or use of social media (3).

Figure 5: Levels of Livestock (5a), Arable (5b) and Non Sector-Specific (5c) Innovations Identified

3.2.6 Goals and Objectives

A range of goals and objectives were cited, however these can be broadly categorised as business objectives and personal / lifestyle choices. However, there was often a strong link between these with respect to succession. A number of respondents noted that they were seeking to expand or consolidate the business because they had a successor; in the absence of a successor some noted they would not be making the same decision. For those respondents who did not have a successor, objectives sometimes related to looking for an 'easier' approach to farming or a reduced workload; for example planning to sell the dairy cows when at the age of 65 and switch to a suckler herd. One

respondent noted the need to keep the farm 'tidy' in case of a farm sale and he liked to keep up to date with machinery in order to make life easier. The most common responses with respect to objectives were 'to make a profit' and 'to keep on farming'. For a number of respondents, a common theme was the need to make a profit whilst maintaining or improving the quality of the land/farm they inherited. Others had specific financial objectives such as reducing the level of debt or making sufficient profit to enable the business to employ labour so that the respondent has an easier lifestyle. In summary many respondents have a list of objectives with a profitable business being of the highest priority, but with a sense that this should not be achieved at the expense of their other objectives.

> *"We try to run a profitable business with a decent lifestyle and to leave it* (the land) *in better order than when we started".*
>
> *"Enable staff and family to have a life other than just farming."*
>
> *"Provide a decent income for the family. Provide a sensible work life balance. Maintain the business so as to be able to hand it over to future generations."*

Respondents were also asked if they were planning any major changes in the next five years. It is interesting to note that the low and medium performing farms more frequently indicated a plan to undertake a major change than respondents in the top performing band. However, interpretation of a major change is important to be placed in context; making a major change may relate to selling the farm as part of the process of retirement as well as changes that will expand or grow the business. Set against this, when asked if there were any barriers to these changes the majority of respondents reported that there were. The most common perceived barriers were the availability of finance and land, together with the volatility of prices received for their products. The lack of land was seen by many to be critical; there was either no supply of land, it was too expensive to buy, or it was not available to rent.

3.2.6.1 Prospects for the Farm Business

The majority of respondents in the survey were very positive about the prospects for their farm business. Two-thirds said they were positive with one-fifth being negative and the remainder being unsure. Opinions were evenly spread across the farm types but there was a tendency for the higher performing respondents to be more positive than the lower or medium performing respondents. Many of the positive comments reflected their evaluation on global issues, while more cautious comments cited specific issues or concerns about future prospects (Table 9).

Table 9: Prospects for the Farm Business

Positive	Cautions
"Prospects are pretty good. Optimism for the future. High demand for food. We are owner occupiers on a solid footing". *"People have been saying since he was at college the world needs more food. Now this genuinely is the case."*	*"Everything we produce will be needed but whether we will get a just price at the end is in doubt. The public will have to be educated how much they will have to pay for it; they've been brought up on cheap food for too long".* *"As we sit here today the prospects are pretty good but 9 months ago this was not the case. Now lower feed costs, 5% more eggs, less labour."*

Specific concerns were also raised in relation to global price determination of pig prices, the asset fixity of pig production increasing barriers to entry and also exit, the possibility of more cyclical milk prices following quota removal and concern over feed input cost volatility driven by world markets. Some of the optimism cited related either to the

success of diversified activities, as these provided a more steady income or spread risk. There was also some recognition from some owner-occupiers that they had a significant asset to sell, if and when they wished to do so. There was no link between businesses that undertook cooperation activities or level of innovation and prospects for the business.

3.2.6.2 Succession Plan for the Farm Business

Approximately one-third of respondents noted that there was a clear succession plan, with just under two–thirds having no clear plan. Respondents citing a succession plan included those with an implicit assumption that their nominated successor would take over the business, yet with no formal plan in place, and respondents with a more formal agreed succession transition. For respondents citing no succession plan, this included situations where their children were not at the point of actively considering taking over the farm as they were still in education. Approximately one-half of the respondents which stated they did not have a succession plan were in this situation. One-fifth of the total sample, were clear that there was no successor, either because there was no one available to succeed or because existing family members had chosen other career paths. There were a few instances (two tenancies and one limited company) where there was no opportunity for succession. Other issues that were cited in relation to succession included farming partnership between siblings, with no formal agreement over succession to their respective children.

3.3 Research Officers' Focus Group Workshop

Following completion of data collection, ROs attended a focus group workshop to discuss the outcomes and key messages that emerged from the case-study interviews. The aim was to draw out the key issues, experiences, opportunities and challenges that they perceived farmers faced with respect to innovation and cooperation. Particular attention was given to whether the results and outcomes were in line with expectations.

3.3.1 Co-operation

Key findings noted were that cooperation was often driven by several factors which can be categorised as either "people", "practical" and "profit". "People" or social factors included the personality of the farmer, their relationship with their farming neighbours and the presence or absence of family members that all affect cooperation. On farms where 'other' family labour was minimal, this typically provided more motivation for cooperation with other farmers. Equally, where farmers with different businesses, but with family connections (e.g. siblings, children, cousins) occurred this was generally noted to increase cooperation. It was also noted, that because the respondents in the survey all participated in the FBS research programme, there was the potential for these respondents to be more cooperative than farmers who declined to take part in the FBS. For 'practical' drivers, cooperation was negatively influenced by a lack of labour availability, concerns over machinery being damaged when 'borrowed', bio-security concerns, and the influence of weather conditions limiting the window of opportunity for harvesting forage and crops. In terms of "profit", it was noted that cooperation had to work financially for each party, and that it was not always cheaper than using contractors, that small farms with low asset bases have more of a need to cooperate in order to justify machinery and that some respondents viewed cooperation as likely to be of increased importance in the future due to the increasing cost and complexity of machinery that will be difficult to justify on small farms. Cooperation was noted to be influenced by geographic proximity and that in some cases farmer discussion groups had provided the contact and interaction that had led to cooperative activity between farmers.

3.3.2 Innovation

With respect to innovation, a clear theme emerged that there was no link to farm performance. Some high performing farms undertook little or no innovation, and

because they were performing (e.g. due to low cost base or favourable land quality to their system) there was no perceived need to innovative. Contrasting this, on some farms where lack of investment had occurred over previous years, respondents recognised the need to innovative and invest. However, a key finding was that approaches to innovation were personality dependent. In terms of farm type drivers, innovations in feeding techniques and breeding were more frequently found on dairy farms, while GPS and yield mapping were most frequently noted on arable farms; with respect to these latter innovations there was also recognition from respondents that they need to be better informed or trained about how to fully utilise these technologies. A key facilitating factor of recent innovative investments had been grants available (Farming and Forestry Improvement Scheme [FFIS]) which were noted as a common driver for farmers investing in new technologies / plant and equipment. One of the most common innovation investments noted by farmers, either as undertaken, or in terms of how they viewed innovation, related to investing in green energy. Some farmers had invested in solar panels, wind turbines or biomass boilers as a way to minimise risk to the farm business and increase business incomes, while others had undertaken these investments in a personal (as opposed to farm business) capacity. In addition to the factors noted above, succession factors were cited as important drivers for investment in innovative practices, while planning and credit opportunities and constraints represented key practical drivers.

3.3.3 Future development

With respect to future studies, the groups noted that it would be useful to clarify particular types of cooperative activity (e.g. machinery sharing, buying groups, members of a cooperative) and innovations (e.g. green energy, new machinery, breeding techniques) in order to fully capture activities occurring on farm businesses, and in particular those beyond 'agricultural production' activities. However, there was recognition that defining both informal cooperation and innovation was particularly challenging.

In addition, ROs provided insights to the key opportunities, challenges and pressures facing agriculture at the present time. Common themes were high land and rental values driven by bioenergy and food demand, hindering individual farm business expansion, but equally providing an appreciating asset against which to secure credit. Renewable energy remains an ongoing opportunity, while access to credit was difficult for some farm businesses, yet straightforward for others; these constraints and opportunities were often observed across farm types, however access to credit for these development projects was most challenging for lower performing tenanted farm businesses. Input and output price volatility was noted to be having attendant impacts for business planning. Implementation of the Common Agricultural Policy (CAP) reform was also cited as a source of uncertainty, while opportunities for investing in machinery and technology in the arable and dairy sectors, to increase efficiency, were cited. Pressures from the abolition of the Seasonal Agricultural Workers Scheme (SAWS), Bovine Tb and other animal disease pressures, and rural crime, remain. Specific farm type aspects were noted; some producers cited that the electronic reporting system for sheep movements is manageable while others noted a reduction in ewe numbers in the Less Favoured Areas (LFA), resulting from the previous harsh winter conditions that had reduced sheep numbers in some areas. In the dairy sector recent price increases have been welcomed but Bovine Tb movement restrictions lead to increased production costs. Pig and poultry producers not committed to feed input contracts have benefited from lower feed costs, while increased output prices have been welcomed. Concerns over regulations and restrictions on crop protection products remain in both arable and horticultural sectors; it is interesting to consider how innovation in the sector will be needed to overcome these challenges.

4. Discussion

The sections below aim to summarise the key findings from the analysis of FBS data, the findings from the case study interviews, and the lessons from the Research Officers' (ROs) workshop, placing these in context with the literature on cooperation and innovation. Policy, advisor and industry recommendations are provided in the following chapter.

4.1 Farm Business Cooperation

Within the FBS data set for 2012/13, levels of labour and machinery sharing were noted to occur on less than 20% of the farms; with respect to all forms of contract rearing of livestock, incidences of this activity appeared to vary by livestock farm type, but were typically in the order of 10-30%. It is informative to note therefore that from the qualitative results of the case studies, four fifths of the respondents interviewed noted that they were involved in some level of informal cooperation, and just under one-half cited some level of formal cooperation. It can therefore be concluded that the data capture within the FBS programme is not sufficiently capturing the breadth of cooperation activities on farms, and consideration should be given towards defining cooperation activities that capture the breadth of examples highlighted in this study.

The motivating drivers for cooperation identified from the case studies were typically financial, efficiency, or scale orientated, reinforcing findings from Klerkx et al. (2010); the ROs workshop identified the key drivers of cooperation as people, practical or profit driven. Typically, the manner of cooperation identified encompassed a range of formal and informal arrangements, which were only partially characterised by exchange of money / no financial exchange respectively. Arable farms were more likely to cooperate than livestock farms, with intensive livestock farmers' expressing concerns over biosecurity. It is interesting to note that Dairy, Cereal and General Cropping farms more frequently cited cooperation as very important to their business, and that this related to their core business activities. Machinery sharing, joint harvesting, lending out of breeding sires and straw for manure swops were all cited as key aspects. It is informative to note the example of dairy and beef farmers cooperating with respect to silage making activities, whereby their respective time frames for this activity facilitated cooperation; hence farm cooperation occurs across farm types, in addition to within farm type collaboration. A further example of cooperation across farm types is captured by straw for manure swops between arable and livestock farms. These activities can be categorised as providing mutually beneficial partnerships (Huggins and Hindle, 2010), which others have identified as facilitated by participation in social and commercial networks (May et al., 2011), in particular when linked to new developments (Snäkin et al. 2010). In recent years, the structures for traditional social networking within the agricultural community have become increasingly specialised within farm type groupings, as evidenced by the decline in major broad agricultural events (e.g. The Royal Show) and the growth in sector specific events (e.g. Cereals; Dairy Event). However, contrasting this, ICT, mobile devices and social networking sites are arguably facilitating networking activities. The ROs workshop identified that personality drivers of the respondent, their relationships with their farming neighbours, and their family connections within the locality, all influenced cooperation activity.

From the case study findings there was some limited evidence of the social drivers of, and benefits from, collaboration (May et al., 2011), while trust between partners was cited as of importance to the working relationship (Gulati et al., 2000). The aspect of breakdown of trust, or of caution with respect to potential cooperation was most evident when considering machinery sharing – motivating factors against cooperation included condition of the machinery on return from being 'shared' and the challenges of allocation of costs of machinery repairs; these factors were evidenced from the case studies and the ROs workshop. There was an isolated example of the regulatory framework surrounding agriculture creating a barrier to cooperation. The use of consultants and

advisors in decision making was most evident on arable farms with an almost universal use of agronomists. The role of innovation brokers has been previously identified as a key cooperative activity that enhances uptake of innovation (Klerkx and Leeuwis, 2009). However, difficulties arose with respect to defining, within the context of the farm business, the level of service that constituted consultancy or advice. In part this arguably related to the individual views of the farmer (e.g. viewing the vet as either advice or as someone who provides solutions to specific problems). Respondents' views on contracting arrangements varied, with some identifying this activity as cooperation, while others viewed this as a service. Irrespective of the manner by which respondents viewed this activity, the case study results indicate that contracting activities occurred on most farms, either as a strategic part of the agricultural activities, or for specific non-central services; there was also recognition that cooperation is not always the most cost effective solution when contractors are able to achieve greater economies of scale and hence offer a more cost competitive approach.

4.2 Farm Business Innovation

The main motivating drivers for innovation uptake related to business or personal lifestyle objectives, which arguably reflects decision making in farm businesses more generally (McCown, 2001; Wallace and Moss, 2002; Bergevoet et al., 2004), of which the approach to innovation is a particular facet of business management. With respect to business objectives of respondents these largely related to 'making profit' or to 'remain in farming', but with a common theme of the need to maintain or improve the quality of the farm or land. With respect to personal objectives, reducing personal labour demands, achieving an easier approach to farming and succession were all cited by respondents as drivers of innovation implementation. Key areas of innovation on the case study farms related to: changes in breeding, health care and feeding policy for animal enterprises; changes to cultivation, harvesting, crop husbandry techniques, including new varieties, and precision agriculture aspects for arable enterprises; and new machinery, plant or software and investment in green energy or energy saving activities across farm types. There was no substantial difference in the number of innovations implemented across the farm types and performance bands from the case study findings. Moreover, the key finding that emerged from the ROs workshop in relation to innovation was that there was no link between innovation levels and farm performance. Moreover, some high performing farms were explicitly not innovating as they did not perceive the need to do so, while some low performing farms recognised the need to invest in their business, and in doing so to innovate, in order to become competitive. As noted for cooperation, innovation was identified as being personality dependent.

Structural innovation at the level of the individual farm business may occur via the purchase of new machinery or plant and equipment, whereby the new investment has technological developments embedded within a recognisable purchase (e.g. GPS embedded within a new tractor purchase). Hence understanding respondents' machinery and equipment strategies is of importance within an innovation context. The most common strategy for machinery and equipment purchase was replacement 'when needed'; however, finance availability and tax incentives towards the purchase of new equipment were cited as key drivers of investment. Contrasting approaches towards the purchase of new machinery and equipment were observed. Some case study respondents cited the process of achieving innovative practices via the use of contractors who could justify the expense of new machinery, while the enterprise or farm size of the farm business made investment infeasible. Others noted that their strategy for machinery purchase was to buy second-hand machinery; while arguably a cost-effective strategy this approach to machinery investment indicates that innovations embedded within contemporary machinery may not be widely embedded within the industry for a number of years – in effect those purchasing second-hand machinery represent adopters of technology at a later time-scale (Vanclay et al., 2013) or are those less willing, or financially less able, to take risks (Läpple and Van Rensburg, 2011). The ROs workshop indicated the importance of FFIS grants as a driver of uptake of innovations, whilst also

noting respondents' desire for training in new technology to accompany such investments; where such bottom-up demand for training courses exist, this research indicates that there is potential for further development of the skill-base in utilising new innovations.

Results from the case study interviews showed that while most respondents were positive towards innovation and innovative practices, small numbers of respondents were very cautious or negative towards innovation, often being linked to a traditional mindset, arguably a proxy for limited absorptive capacity to consider innovative practices (Cohen and Levinthal, 1989, cited by Huggins and Hindle, 2010), not being willing to take risks (Abadi Ghadim and Pannell, 1999; Knowler and Bradshaw, 2007), expense of new technologies, or the financial constraints of individual businesses (Carruthers and Vanclay, 2012; Pannell et al., 2006). These later points were explicitly highlighted by three quarters of the case study respondents that there were practices and innovations that they could undertake in their business, but which they were either not currently undertaking, or were not in a position to do so. Frequently, these innovations related to changing enterprise scale or the adoption of new technologies or approaches, e.g. GPS, robotic milking, changing breeding policies or investment in new buildings. However, where these innovations were not adopted, the constraints cited related to the cost of implementing the change, in part reflecting smaller business or enterprise size (Huggins and Hindle, 2010), concurring with previous findings that identified that larger businesses are more likely to implement innovative practices (Diederen et al. 2003b; Smit and Smithers, 1992; Fuglie, 1999, cited by Knowler and Bradshaw, 2007).

Case study respondents typically kept up to date with new technical developments via the farming press, workshops, technical events and via advisers, be these independently paid for, or those provided as part of product purchase (e.g. agronomist advice alongside crop protection purchases). The combination of approaches to obtaining information was also reflected in respondents' advice to others about innovation – 'positive but cautious', noting the need to learn from a range of sources. The level of information sharing about technical developments that occurred between farmers was relatively common and represented a clear message from respondents to 'learn from other farmers'. These approaches to learning about new developments reflect findings previously noted in the literature where individuals need to identify and assimilate knowledge in order to exploit this in their own business context (Cohen and Levinthal, 1989, cited by Huggins and Hindle, 2010). Typically respondents with lower levels of engagement in discussion groups were in the lower and medium performance bands. In terms of specific aspects of training and qualifications, larger farms and businesses typically held a more positive view of, and approach to, training staff and attending technical courses. These differences in approach to training are argued to result from a combination of cost barriers and social or objective influences (Carruthers and Vanclay, 2012). Hence, reducing cost barriers may only partially change behaviour towards uptake of training.

Uptake of innovation or technological advances will arguably occur more frequently in an industry or sector where business owners' perceptions about future prospects for their own business and the industry are positive. Of the case study respondents, two-thirds were positive about prospects for their own business, with respondents citing the global drivers of demand for agricultural products. Moreover, succession within individual businesses was cited by the ROs workshop as an important driver for the uptake of new technologies. This arguably reinforces Renwick et al.'s (2014) recommendation to embed greater cross-fertilisation of agricultural subjects alongside specialised knowledge in the education sector to provide an efficient medium of communication to influence business successors explicitly, and some established farm business managers indirectly.

5. Recommendations

Advice and policies focused around cooperation and innovation that articulate financial, efficiency and labour saving advantages will more directly meet the needs of farmers than those which are focused around associated factors. For example, innovations which reduce fuel use should be articulated in terms of cost saving benefits, rather than the wider environmental benefits of the innovation. Greater cooperation aimed at the arable sector will arguably be more effective than the livestock sector; however cooperation across farm types has been identified as providing mutual benefits. Advice and policies which recognise local needs in addition to the role of local networks in articulating policy messages will enhance effectiveness. While financial drivers are central to cooperation and innovation uptake, these must be accompanied by other enabling aspects as discussed below.

The farming press remains a key medium of communication and promotion of information. However, farmers are increasingly reliant upon sector-specific events, advisers, ICT, mobile technologies and social networks to engage with other farmers and the wider industry. With respect to innovation, learning from other farmers was a recurring theme and one which enhances farmers' absorptive capacity. Advice and policies should therefore be targeted via a range of innovation broking pathways and communication channels and accompanied by incentives which encourage uptake by "early adopters", conditional upon the hosting of on-farm demonstrations or on-farm training events. The use of demonstration farm hosts offers multiple benefits whereby farmers can obtain practical, contextual, localised information across a range of innovations and technologies within a limited timeframe.

Scale efficiency financial constraints, and greater levels of relative risk of embedding a new practice or innovation, occur on smaller and medium sized farm businesses that are unable to justify expenditure on new technologies; these constraints can be relaxed via cooperation between farmers or via the use of contractors. With respect to machinery sharing a major constraint relates to the challenge of attributing machinery repair costs between businesses. Advice and policies which recognise and incentivise joint machinery investment, together with guidance and simple protocols for on-going cost sharing between businesses would both incentivise innovation on smaller and medium size farm businesses, and lower barriers to ongoing cooperation. Incentives which encourage uptake of new innovations in the farming sector should recognise the role that contractors play in enabling small and medium sized businesses to obtain scale efficiency innovation gains via alternative business models.

Financial incentives, in the form of tax incentives, grants, or interest free (or low interest) loans for new plant and machinery purchases have a direct impact on uptake of new machinery and technologies. In order to further increase innovation uptake, policies supporting financial incentives should be maintained and extended. In order to achieve greatest benefit from the use of new technologies, financial incentives should be combined with training provision in the use of new technologies (e.g. training in use of GPS enabled equipment). The cost of attending training courses was identified a barrier to uptake on small and medium sized farm businesses; financial incentives to reduce or eliminate this cost will incentivise uptake of training provision, while recognising that there are wider social and individual barriers to the uptake of training which represent more challenging areas for policy implementation.

Defining both informal cooperation and innovation is particularly challenging but in respect to future studies, it is necessary to clearly clarify particular types of cooperative activity (e.g. machinery sharing, buying groups, members of a cooperative) and innovations (e.g. green energy, new machinery, breeding techniques) in order to fully capture activities occurring on farm businesses, and in particular those beyond 'agricultural production' activities. The qualitative case studies show that existing data

may not fully capture the full range of co-operation and the complexities in understanding innovation from a farmer perspective.

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Appendix 1: Literature Review

Objective

The main objective of this literature review was to identify the key factors driving innovation and co-operation in agriculture, by searching the main English language databases for the last 10 years, in addition to reviewing publications from governmental and cross-national organisations, including Defra, OECD and USDA.

Particular emphasis was placed on research based on observations to provide empirical results, and whilst the main focus was on experiences within the UK, comparisons were also drawn from other countries within the EU, as well as other developed countries including the USA, Canada, New Zealand and Australia. Key research studies from countries outside this remit, as well as studies drawing from data captured pre 2004 were also reviewed where their findings were of particular interest and relevance to this case study.

Methodology and Sample

The primary search focussed on academic databases including Web of Science and Science Direct, using the key words agriculture, innovation, co-operation, technology and farm performance, to filter the most relevant studies. This primary search was also replicated using Google Scholar to capture any additional material. The abstracts of the positive results from this primary search were then filtered by applying a scale of relevance to this case study to draw down the results to give an overall detailed review of the most relevant studies. The same search criteria were also applied to the most recent publications from Defra, USDA and OECD.

Quantity and Quality of Evidence

Using the search methodology as described above, the number of positive results for 'agriculture' + 'innovation' were 40,415 searching Science Direct and 1,793 in Web of Science. When 'performance' was added to the search criteria, 404 and 121 records were found respectively. An additional seven references were highlighted using Google Scholar as a search engine. The articles were then filtered still further, depending upon the relevance of the subject title and repetition. The abstracts of approximately 48 research articles were then reviewed, with the papers most pertinent to this Case Study read in more detail. When the search was duplicated, using 'co-operation' in place of 'innovation', far fewer positive records were found, with 180 in Science Direct, and 18 in Web of Science. Again, an initial screening of the article title, followed by a more detailed review of the most relevant abstracts, resulted in 13 research papers being read in full. To support the academic evidence, a comparable search of applicable government policy documents was conducted, including, for example, the OECD ilibrary and Defra. Where appropriate, the most current publications from examples of the farming press were included, in order to provide background information. As the above figures indicate, more literature relating to innovation in agriculture than for co-operation was found, and in particular there was a noticeable lack of research regarding informal co-operation between farmers. However, there was good evidence of current research for both areas of interest, and in particular from international sources.

For ease of referencing and application to the Case study questionnaire, the review has been divided into two broad sections relating to Farm Business Innovation and Farm co-operation. However, as there are a number studies that cross both fields of research, there is a degree of overlap in the presentation of the reviewed literature.

Farm Business Innovation

The Definition of Innovation

The Oslo Manual (OECD and Eurostat, 2005) defines innovation as *'the implementation of a new or significantly improved product, process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations'* and that whilst "innovation must contain a degree of novelty, not every new idea is innovative". The Oslo Manual distinguishes three types of novelty, these being: an innovation can be new to a firm, new to the market or new to the world. The first concept concerns innovations that already exist, i.e. one which has been implemented by other businesses already, whilst businesses that develop innovation are classified as drivers of innovation (Huggins and Hindle, 2010). The US Advisory Committee (2008) defines innovation as *'the design, invention, development and/or implementation of new or altered products, services, processes, systems, organisational structures, or business models for the purpose of creating new value for customers and financial returns for the firm'.*

The Process of Innovation

The innovation process has been defined as comprising three main stages: i) sourcing of information and knowledge, ii) transformation of knowledge into innovation output, and iii) capitalising on this output to maximise profit and growth (Hansen and Birkinshaw, 2007). Le Gal et al. (2011), argue that within agriculture, three actors were defined in the process of designing innovative production systems - farmers as decision makers, advisors as support providers and researchers as producers of both technical and methodological knowledge, with agricultural researchers also assisting in the ex-ante evaluation process of the innovation to be considered.

Agricultural Innovation Systems

Agricultural Innovation Systems (AIS) are of fundamental importance to improving the economic, environmental and social-performance of the agri-food sector (OECD, 2013) Traditionally, the key aim of AIS has been to accelerate the rate at which adoption of innovation occurs, in order to stimulate productivity and competitiveness in the agriculture sector, whereby a transfer of knowledge automatically results in a performance enhancing technological change for farmers (Stephenson, 2003). However, it has been argued that this hierarchical, linear model failed to take into account the specific needs of an individual, nor the socio-economic, institutional, environmental and organisational characteristics of the farming system (Pascucci and de-Magistris, 2011). The use of Agricultural Innovation Systems (AIS) to analyse technological, economical and institutional change in agriculture have become increasingly popular (Spielman et al., 2008). More recent views of innovation systems define these as a network (rather than a linear paradigm) of institutions, firms and individuals interacting to design, assist encourage and implement innovations (Rajalahti et al., 2008). Within an Italian context, Pascucci and de-Magistris (2011) showed that attention would be better focussed on local dynamics and rural interaction, in order to maximise and enhance the usefulness of AIS in stimulating farmers to adopt innovative technologies and ideas in order to improve performance. Within the Irish Agrifood sector, Renwick et al. (2014) analysed the factors influencing Agrifood Innovation Systems (AFIS) focusing upon influences along the agrifood supply chain. With respect to farm-level uptake of innovation, Renwick et al. identified that innovation was positively associated with higher farm incomes, larger farms, younger farmers, more intensively farmed businesses, greater educational attainment and having access to credit. However, it is important to note that Renwick et al. in part defined innovation uptake as measured by investment in machinery and equipment, and recognised that the causal link between investment and farm size/performance is unlikely to be unidirectional, but that more profitable

businesses are also more able to undertake capital the capital investments which were defined as a proxy for innovation. In order to facilitate innovation with AFIS, Renwick et al. recommended changes tax incentives for medium to large-size agrifood companies, strengthening research-industry engagement, focus industry-academia linkages on added value products, facilitating industry collaboration and innovation forums and utilising Common Agricultural Policy funding to financially incentivise innovation practices at farm level.

Key Drivers behind Innovation

Key drivers of innovation are dependent upon the nature of the innovation and the type of business involved, with both internal and external factors having an impact on the adoption of innovative practices, and in particular the 'absorptive capacity' of a business to "identify, assimilate and exploit knowledge" (Cohen and Levinthal, 1989, cited by Huggins and Hindle, 2010). The absorptive capacity of an individual business is determined by a wider range of factors outside of the direct control of that business. The skill and adaptability of an individual, which may be developed through formal and practical training, are key factors, as is the ability to procure funding, either internally or externally. Smaller and less well established businesses are more likely to reject or abandon the uptake of an innovative technology or idea as they are less likely to have internal finances on which they can draw, when external funding is not available (Huggins and Hindle, 2010). The stimulation of and response to demand from the potential innovator through to the end user are also important factors in successful adoption of new ideas, in addition to socio-cultural factors such as entrepreneurship and level of risk aversion. Information and Communication Technology (ICT) infrastructure has also been shown to influence uptake of innovative practices, playing a crucial role both in the way that businesses innovate, and in the innovation itself (Huggins and Hindle, 2010).

Factors affecting the decision-making process

The process by which farmers make decisions regarding their business can be classified into three distinct categories, namely operational (day to day management decisions); sequential or tactical (decisions made within a growing season) and strategic (having an impact on the structure of the farm over many years) (Bouma et al., 1999, see Janssen and van Ittersum, 2007). In reality however, decisions made by farmers are motivated by multiple, often conflicting, objectives as farmer behaviour reflects a combination of personality factors as well as lifestyle and economic objectives (McCown, 2001; Wallace and Moss, 2002; Bergevoet et al., 2004).

Social Influences

Adoption and innovation involve complex social processes. The reasons for adoption or non-adoption may result from external influences, with an individual, or with other decision makers within a family farm business. Farm businesses display a high degree of diversity in type and structure and therefore new practices or technologies are rarely universally applicable (Howden and Vanclay, 2000, cited by Carruthers and Vanclay, 2012). The stage a farmer is at in their lifecycle has also been noted to impact on their decision-making process; a farmer at the early stage of their career or business life cycle is likely to have different priorities and ideas compared to a farmer considering retirement (Carruthers and Vanclay, 2012).

Decision-making is often influenced by an individual's perceived impact on their level of well-being or "utility", with many agricultural economic models using profit as a more measurable, albeit non-universal, substitute for utility at the firm (farm) level. A range of factors including; farm household and farmer characteristics, farm business structure, socio-demographics and type of innovation in question are perceived to affect the

outcome of a farmer's decision making process (Edwards-Jones, 2006). Whilst farmer age, education, gender and attitude to risk, as well as stages in the family cycle and physical characteristics of an individual farm (type, size and level of financial stability) are known to have an important influence on the decision making process, social attitude and capital, availability of information and the impact of current policies are also of relevance (Solano et al., 2003).

The Theory of Planned Behaviour, utilising the role of farmer attitudes and the expectation of success has been used as a theoretical basis for understanding farmer decision making in numerous studies. Behaviour may also play pivotal role in the farmers' decision making process, and although particular characteristics of an individual and their self-perception are likely to have a positive impact on technical and financial efficiency of the farm business, these perceptions are subject to change over a period of time (Wilson et al., 2013). Understanding why farmers behave in a particular way could provide some explanation as to the wide ranging degree to which innovative practices are adopted by some and not others. Herzfeld and Jongeneel (2012) illustrated the importance of both psychological and sociological studies when looking at the drivers behind farmer behaviour. Limitations were found with the classical economic approach of cost-(forgone) benefit when interpreting compliance of farmers to mandatory regulations, such as Statutory Management Requirements (SMR'S). Factors such as intrinsic motivations, moral convictions, social preferences and the impact of peer groups were also introduced in the study in order to provide a more robust determination of why farmers behave in a particular way when it comes to the process of decision making (Herzfeld and Jongeneel, 2012).

Using the Theory of Reasoned Action, Rehman et al. (2007) explored the socio-psychological reasons why not all 500 livestock farmers in the South West of England adopted new milk production system technologies, despite evidence of economic potential. This study focussed on the Milk Development Councils' (MDC) recommended observation times for heat detection. An individuals' disposition and perception (of social pressures) both impact on their intention to behave in a particular way, with their beliefs about the outcome of a course of action, and an evaluation of the expected outcome playing a key role in the process of decision-making. Rehman et al. found that 10% of respondents were using the MDC observation times, with a negative intention to adopt by those not already doing so. The results indicated that key drivers for adoption included cost effectiveness, improved detection and conception rates (Rehman et al., 2007). However, they also found that whilst there were one or two isolated barriers observed (e.g. for farmers less than 41 years of age, although not totally prohibitive, staff training was likely to be an issue), there were no key barriers to adoption, leading them to suggest that farmers' perception of MDC observation times may have been more positive with more effective promotion.

Utilising FADN data, Finger and El Benni (2013), analysed Swiss farmers' adoption decision within the context of extensive wheat production, as part of an ecological direct payment scheme. Finger and El Benni found that smaller farms who already farmed less intensively were more likely to adopt extensive wheat production in the first instance, with more intensively farmed land less likely to be moved to into extensive management, despite the fact that extensive wheat production was found to be slightly more profitable, once reduced input costs, forgone revenue and ecological payments have been taken into account. Fluctuations in wheat price and the level of ecological subsidy payment were also found to have a significant influence on the adoption decision by wheat growers. Factors influencing the uptake of agri-environmental schemes (AES) are known to be influenced by farm and farmer characteristics, attitude towards risk and the nature of the scheme (Knowler and Bradshaw, 2007). A direct correlation between farm size and willingness to invest in new technology has been shown in a number of studies (e.g. Smit and Smithers, 1992; Fuglie, 1999, cited by Knowler and Bradshaw, 2007); although Knowler and Bradshaw (2007) indicated that overall this relationship

was inconclusive. In addition, although farm location and soil type was also found to be a contributing factor to the level of adoption, farmer awareness of soil erosion was probably a more defining factor. Knowler and Bradshaw (2007) also reviewed the impact of the financial characteristic of an individual farm on the adoption of conservation agriculture and again found no overall consensus of opinion across the 31 studies reviewed, or with respect to tenure or financial well-being of the farm.

Risk

Farmers face risk and uncertainty about the economic and environmental consequences of their actions, due to a limited ability to predict variables beyond their control (namely non-embedded risks including prices, biological responses and the weather (Pannell et al., 2000). However, in the uptake of innovative practices, a farmer faces a degree of embedded risk, whereby there is the opportunity to assess the risks inherent within a given agricultural innovation (Dorward, 1999, cited by Janssen and van Ittersum, 2007). Typically research by both economists and sociologists focuses on the characteristics of the adopters or the innovations in question (Marra et al., 2003). Of particular importance is the need to distinguish between different aspects of risk; namely farmers' perceived risk regarding new technology, a farmer's individual attitude to risk, the role of learning and on-farm trialling, and the possible benefits of delaying the adoption of innovative technologies.

Conflicting evidence regarding the level of a farmer's risk aversion and whether they were likely to be an adopter or non-adopter indicates that risk preferences differed depending on a particular situation and point in time. A three year study of crop producers in Western Australia concluded that risk aversion tended to reduce adoption (Abadi Ghadim and Pannell, 1999), whilst King and Robison's (1981) study of attitudes towards double cropping in the USA reporting contrasting findings (cited by Marra et al., (2003). Level of farmer education was found to affect the level of an individual's risk aversion, with higher levels of formal agricultural education associated with greater adoption of an innovative technology (May et al., 2011).

Income variability

Bio-economic farm models (BEFMs) have been widely used to provide an ex-ante assessment of the link between factors affecting a farmer's decision making process and the subsequent impact of policy changes and technological innovations. Theory and knowledge of farm processes provide the building blocks for Mechanistic BEFMs, which serve to provide a link between a farmer's resource management decision with the necessary inputs required to achieve certain outputs (Janssen and van Ittersum, 2007). However, whilst many such models exist, limitations with data sourcing, linking findings with end-users and overall evaluation of the model in question were found.

A whole farm model was applied in a recent study of arable farmers in Western Switzerland (Lehmann et al., 2013). Yield records from the Swiss Farm Accountancy Data Network (FADN) were used to support field trials in the simulated model that investigated the impact of likely changes in climate and crop prices and subsequent management decisions of farmers in response to such changes. The study concluded that management decisions such as fertiliser applications and irrigation strategies were affected more strongly by EU crop prices and potential impact on income variability than by climate change. Income variability was also a key factor affecting the perceived utility to be derived from growing energy crops (Paulrud and Laitila, 2010); results from a study of Swedish farmers suggested that willingness to grow energy crops would be significantly influenced by visual impact of such crops, farmer age, farm size and the geographical area. Farm size has also been identified as a key driver of innovation, with large scale farmers having increased accessibility to funding (May et al., 2011). Land

tenure and farm type, however, were shown to have an insignificant effect on the farmers' willingness to grow energy crops (Paulrud and Laitila, 2010).

The adoption of innovative technologies and ideas and subsequent impact on farm performance may also be influenced by specific grants (i.e. Rural Development Programme for England (RDPE)). Whilst the objective of these grants may be aimed at animal welfare or environmental protection, there is often a positive impact on farm performance (Defra, 2014). The uptake of AES illustrates how financial incentives, in conjunction with social benefits, may encourage adoption by farmers; conversely, negative influences were the voluntary nature of such schemes, the application process itself and the overall logistics of scheme implementation and subsequent management (Edwards-Jones, 2006). Whilst the financial capacity of a farmer has been shown to have an impact on the potential uptake of innovative technologies and ideas, Carruthers and Vanclay (2012) noted that difficulties arose when assessing the causal direction between higher incomes and adoption of innovative ideas or vice versa (Pannell et al., 2006).

Policy Making

Qualitative analysis of an interview-based study to determine the decision making process behind the adoption of bioenergy production by Finnish farmers (Snäkin et al., 2010) illustrates the importance of business and marketing knowledge, innovation and financial abilities, education level and networking skills. Farmers in the Oulu region of Finland were categorised as investors, entrepreneurs and hobbyists depending upon the extent to which they displayed commitment to bioenergy production. Producers' decision making was affected by both farm related factors - financial, labour and machinery resources, as well as personal capabilities, but also by regional factors, such as transport and communication infrastructure and energy markets; these later factors often outside the control of the decision maker. Snäkin et al. (2010) defined 75% of farmers as investors or entrepreneurs, with 25% as hobbyists, indicating that motivation of Finnish farmers was not the major barrier in the adoption of bioenergy production. Funding, training and networking were cited as crucial to the successful uptake of bioenergy production; lack of cohesion between national and regional policies was a major obstacle to a more sustainable national energy economy (Snäkin et al., 2010).

Motivation and Barriers to the Adoption of Innovation

Process of Adoption

The process of adoption commences with the potential adopter being aware of the existence of an innovation, how it functions and whether it might be applicable to their individual situation, leading to the formation of an opinion on the value of the innovation. Following this, a choice is then made whether to adopt or reject the innovation, leading on to potential implementation. However, the final decision depends upon positive re-enforcement or negative re-evaluation. Adoption is most likely to occur when the innovation fits with the adopter's own circumstances, beliefs and practices (Vanclay, 2004); when information about the innovation is available (Diederen et al., 2003a) and when innovations have a high relative advantage (Pannell et al., 2006). Vanclay (2004) states that there is "no such thing as a barrier to adoption, only legitimate reasons for non-adoption, with those reasons often making sense from the perspective of the non-adopting farmer".

For implementation to be successful, innovation has to occur at all points along the value chain; from research, development and extension (via agricultural consultants), through farmers as individuals and as decision makers within the farm business, to consumers and governmental policy makers. It has also been suggested that government regulatory bodies could be seen as 'innovation gatekeepers' and may exacerbate this lag in the uptake of new technologies. The diffusion of a new technology must also be taken into

account, as the degree of novelty will also determine the speed with which that technology is embraced. Initial rate of adoption tends to be slow, due to limited information and higher perceived risk. The more farmers that adopt a particular technology however, the risk is reduced and eventually adoption uptake levels off, as the technology loses its 'innovativeness' (Läpple and Van Rensburg, 2011).

The all-encompassing definition of innovation leads us to believe that everyone is both innovative and an innovator in one way or another, but may work on a different timescale to others (Vanclay et al., 2013). Farmers were categorised as innovators, early adopters and "laggards" by Diederen et al. (2003b), who analysed survey and interview data from a selection of farms from the Dutch Farm Accountancy Data Network (as well as from a supplementary group of farmers identified as potential innovators) in order to assess the likely factors affecting the 'early' or 'late' adoption of new agricultural technologies. Contrary to other studies at the time, they opted to examine a large range of innovations rather than one specific innovation, with a view to gaining a broader insight into the timing of the adoption process, although this method did have one key disadvantage, as small low cost innovations were compared with large, high cost ones. Diederen et al. (2003b) concluded that several structural factors had a significant impact on whether a farmer was an innovator or early adopter, compared to one which was a late adopter, or chose not to adopt a particular technology at all. Larger businesses were more likely to adopt new innovations earlier, as were those farms that supplied more heterogeneous markets and those that had internal capital for potential investments. Younger farmers, often with higher levels of formal education and enhanced reliance on external sources of information, were found to adopt innovations earlier; conversely older farmers were likely to be working on a shorter time scale and therefore less inclined to invest in new technologies. Farmers were also likely to adopt earlier when they considered the search for innovation as a fundamental part of their management strategy, with a natural progression to follow-up activities. The number of technological opportunities available varies considerably from one farm type to the next and has been shown to have a positive impact on the speed of adoption, whereas regulation and market protection are known to have a negative impact (Diederen et al., 2003b).

Social Factors

A range of individual social (age, gender, education, cognitive skills and motivations) and institutional factors (policies, regulations and incentives) have been suggested as influencing the uptake of innovations (Pannell et al., 2006). The family situation of the farm business also plays a significant part in the adoption of innovative agricultural techniques, where a majority of farmers are not sole operators but run the farm with family members, sometimes representing more than one generation. Adoption discussions therefore may not rest solely with a specific farmer but rather with all members of the family farm business (Vanclay, 2003; cited by Carruthers and Vanclay, 2012, and Vanclay, 2004).

Australian farmers have been recognised as leading adopters of new technologies (Guerin, 1999; cited by Carruthers and Vanclay, 2012), resulting from the need to adapt to an ever changing climate, isolation and a move away from a European based agricultural system. Additional emphasis on natural resource management and improved environmental management has also encouraged uptake of new technologies and land management strategies. The implementation of Environmental Management Systems (EMS), while not a new concept worldwide, was nonetheless seen to be an innovative idea by a study group of farmers in Australia (Carruthers and Vanclay, 2012). The impact of social factors affecting the uptake of EMS was incorporated into Carruthers' and Vanclay's study, including how management decisions were made, who was responsible for those decisions, the lifecycle of the farmer and the effects of peer pressure. Some farmers who participated in this particular study stated that "their neighbours already thought that they were a bit unusual anyway", so this didn't impact

on their decision to adopt Environmental Management Systems (EMS). Their study also commented that Parish (1954) had previously observed that newcomers to an area, or to farming in general, already felt like outsiders and thus were "better able to risk their neighbours' ridicule" if newly adopted techniques failed. Whilst the financial capacity of farmers (Barr and Cary, 2000, cited by Carruthers and Vanclay, 2012) is a major consideration, it is also important to note that for many farmers profit is not the main driving force for change and therefore economic incentives alone are not enough to promote adoption (Vanclay, 2004).

Motivations for the adoption of Renewable Enterprises (RE) were found to be entrepreneurial; with cost reduction, a desire to diversify and an interest in providing environmental benefits proving to be the three most important factors (Mbzibain et al., 2013). Mbzibain et al.'s study of 2000 farms in the West Midlands concluded that adopters of RE were significantly different from non-adopters in terms of farm size, structure, tenure and age of farmer. They found that younger, better educated cereal and lowland grazing farmers were more likely to adopt RE. The current adopters reported that their farm business performance had either stayed the same or improved, with 75% considering expansion into RE in the future. Barriers to the adoption of RE were found to include prohibitively high investment expenditure, small farm size and unsuitable infrastructure or location of the farm. Both dairy and younger farmers, especially those with higher levels of education, voiced concerns about increased labour inputs resulting from potential investment; farmers in general are less likely to invest in enterprises that require additional labour (Mbzibain et al., 2013). Mbzibain also identified that the main source of funding for RE was from either personal or business resources, although the introduction of renewable heat initiative and feed in tariffs are likely to explain farmers' interest and potential intention to invest in solar and wind enterprises, rather than the more costly and complex anaerobic digesters. Indications that the availability of government funding was of key importance when a farmer was making the decision to invest in RE or not were also identified by Sherrington & Moran (2010), with Adams et al. (2011) arguing that without the availability of government grants, few farmers would invest in RE (cited by Mbzibain et al., 2013).

Karsh et al. (2013) examined the barriers identified by market gardeners in the USA as potential adopters of ergonomic innovations, compared to individuals with little or no interest in adopting. An intervention study of eight hundred and forty eight market vegetable farmers found that cost, a lack of information, novelty of the innovations in question and limited field trials were all prohibitive barriers to the uptake of several ergonomic innovations, with a potential to reduce demand on the musculoskeletal system of horticultural farm workers. The study hypothesised that farmers unlikely to adopt were in either the awareness, persuasion or decision stage, whilst those likely to adopt were in either of the latter two stages. Diffusion of innovation theory states that in the awareness stage, individuals know about the existence of an innovation and the basis on which it functions. The individual then forms an opinion of the innovation in the persuasion stage, depending on perceived benefits of cost, profitability, ease of use etc. (Karsh et al., 2013). At this stage an individual will either choose to reject or adopt the innovation, or may move into the decision stage, where trialling of the product will help the individual with their final decision on whether to adopt or not. Ideally, the adoption of an innovative practice by a farmer would incorporate on farm testing, whereby allowing the farmer to assess the benefits of a specific innovation in situ. In reality, this would be a potentially time consuming, risky and expensive process. Farm advisors may provide an alternative solution however, by their capacity to evaluate the potential impact of an innovation on the structure, functioning and performance of an individual farm and within the context of a communication platform, incorporating researchers, advisors and farmers (Le Gal et al., 2011). Factors found to be of importance to likely adopters were primarily concerned with a desire for additional information regarding the ergonomic innovations, in addition to the ability to see the innovation put into practice, either on demonstration farms or in field scale research. Unlikely adopters were found to

have different needs, with emphasis placed on costs vs savings and potential gains in productivity and efficiency.

Although many studies have focussed on innovation at farmer level, it is prudent to consider innovation throughout the value chain as a whole, from research and development, through agricultural consultants and farmers themselves, to consumers, government regulatory authorities and policy framework. For innovation to be successfully adopted, the process has to traverse all points on the value chain. Using Genetically Modified (GM) crops as an example, development and marketing of seed through to acceptance by the end market, the innovation must be expected to succeed within a commercially viable timeframe (Vanclay et al., 2013).

Technology Assessment

Agricultural sustainability in social, environmental as well as in economic terms requires ongoing innovation by farmers (Bruce, 2002; Salleh, 2006, cited by Vanclay et al., 2013). It is important to highlight that the concept of innovation is also important at policy level, in order to provide governance and regulation of new technologies in agriculture. Whilst the adoption of new ideas and practices may be enhanced by agricultural policy, it may also have the reverse effect, of supressing adoption of innovative technologies (Carruthers and Vanclay, 2012). Technology assessment (TA) is well-established worldwide and is a concept familiar to many OECD countries. It is thought to have originated in the United States in the 1960s, although the demise of its use in the USA has led to calls for its re-introduction (Erikson, 2010; see Vanclay et al., 2013). Historically, TAs failed to take into account social factors, although more recently have been modelled on four key variants; namely participative, interactive, constructive and "real-time" (Vanclay et al., 2013). They are now defined as "an applied process that considers the societal implications of technological change in order to influence policy to improve technology governance" (Russell et al., 2010).

Technology Assessments may take the form of parliamentary bodies, independent statutory authorities or be based at academic institutions and their overriding function is to strengthen the decision making processes in relation to technology and to provide information about technological developments in industry. Expanding on this remit, TA's seek to encourage public acceptance and provide information for the adoption and management of new technologies.

The Science and Technology Options Assessment (STOA) is an official agency of the European Parliament and to illustrate the function of TAs in an agricultural context, a number of European TA agencies have contributed to the debate on GM crops in terms of agri-sustainability (Bűtschi et al., 2009). Specific examples include: the use of Technology Assessment to guide policy makers in Germany, through the exploration of the potential opportunities associated with new energy crops (Meyer et al., 2007, cited by Vanclay et al., 2013) and the Danish Board of Technology, who, through the use of TA provided guidance to policy makers, regarding public perceptions and acceptability for the use of GM plants for developments in medicine and industry (DBT, 2006, cited by Vanclay et al., 2013). Vanclay et al. (2013) conclude that the use of Technology Assessments has the potential to enhance innovation at all levels of the value chain, thereby increasing the effectiveness of the design, introduction and governance of new technologies.

Additional evidence relating to adoption of innovative techniques is provided in an Interim Defra Report entitled "Opportunities and Barriers to Business Innovation in Rural Areas" (Huggins and Hindle, 2010). Key barriers highlighted by the report focus upon a smaller, less diverse labour pool, limitations in ICT infrastructure, distance from market and limited financial availability. The report does suggest, however, that innovative rural

businesses are able to harness motivation and a willingness to adopt new technologies and ideas to overcome these disadvantages, with opportunities such as renewable energy specific to rural businesses. The report also suggests that, statistically, there is little difference between rural and urban firms using a variety of indicators of innovation, although on the whole, the extent of innovation is less intense in rural firms. Whilst only minor intra and inter regional variation of innovation was found to exist, peripheral areas including the North East and South West displayed some aspect of weak performance, whilst rural businesses in East Anglia showed a higher level of innovation (Huggins and Hindle, 2010).

Agri-research

Across the world, agricultural systems are facing a multitude of challenges, as a result of irregular production levels, fluctuating input and output prices and the impact of agricultural activities on the environment (Le Gal et al., 2011). Agri-research aims to provide solutions to these challenges, through innovations applicable at the farm level. Advances in cropping and livestock systems strive to provide the high level of productivity required to feed a growing world population, whilst maximising environmental benefits through the use of renewable resources, natural processes and biodiversity conservation (Keating et al., 2010, cited by Le Gal et al., 2011).

Whilst there are many similarities between innovation in agriculture and innovation in other industries, there are a number of important differences, including the demand for adaptive research in response to uncontrolled factors such as co-evolving pests and diseases and climate change (Pardey et al., 2010). Evidence also indicates that funding for agricultural research is moving towards the environment, issues of food safety and security and human health, and away from farm-productivity enhancement. In 1999 there were in excess of 150 studies conducted on sheep-specific subjects in 49 different research institutes within the UK, with funding amounting to more than £21 million (Anderson, 2001). One major element of this research and development was highlighted as Technology Interaction (TI), where there was close correlation between the level of uptake of new technologies and the degree and clarity of communication between promoters and adopters of innovation. Anderson also suggested that rather than a "push" of new technology by researchers, a "pull" from farmers and processors was likely to encourage uptake of new technologies by the "average" farmer. The development of Monitor Farms in New Zealand illustrated the benefits of technology transfer, through collective learning and focus groups, leading to management practice and performance changes (Anderson, 2001). Technology Interaction provides historical evidence of the fundamental importance of primary consultation with the potential end users of new technology, with the current Agri-Tech Strategy striving to take this concept into the future.

Agri – Tech Strategy

The overriding vision of the UK Agri-tech strategy is that the UK "becomes a world leader in agricultural technology, innovation and sustainability; exploits opportunities to develop and adopt new and existing technologies, products and services to increase productivity; and thereby contributes to global food security and international development" (BIS report, 2013). The primary goal is to determine how the UK can meet the challenge of feeding a growing population, without damaging our natural environment, and for the UK to regain its world-leading role in the race for better, more efficient and more sustainable agricultural production. For this to be successful, the connection between basic research and applied science must be re-established, to facilitate the creation of a modern system within the UK, consequently making agri-tech expertise available to all UK farmers and growers and allowing them to take full of advantage of innovative techniques, in order to maximise profit and sustainability. The agricultural industry has already illustrated how this can be done by, for example, using

Global Positioning System (GPS) and precision farming techniques to ensure more targeted application of inputs.

Precision Agriculture Technology

Precision Agriculture has been defined as the "electronic monitoring and control applied to data collection, information processing and decision support for the temporal and spatial allocation of inputs for crop production" (Bongiovanni and Lowenberg-DeBoer, 2004). It encompasses any method using precision measurements to aid crop and livestock farming, with the most basic type being soil sampling and GPS mapping. The data obtained can then be used through complex decision support systems and IT technology to produce nutrition maps, which can then in turn be used to minimise inputs and maximise output. Key factors affecting a farmer's intention to adopt precision technologies have been critically reviewed, using predictive (ex-ante) and utility (ex-post) based modelling (Pierpaoli et al., 2013), with the former focussing on the acceptance of a new technology prior to its introduction, and the latter on the motives behind a farmer's adoption of new PA technology. Increasing profitability has been attributed as the main motivating factor behind the desire to adopt new technology (Adrian et al., 2005; Aubert et al., 2012), with the Perceived Usefulness (PU) of a system being a key driver of adoption, whereby a farmer who perceives a technology as useful and easy to use is more likely to adopt that technology (Davis, 2004, cited by Aubert et al., 2012, and Pierpaoli et al., 2013). Pierpaoli et al. (2013) identified several factors influencing actual uptake of PA technologies: farm size, soil quality and location (contingent factors); farmer's age, education, level of computer literacy and access to information (socio-demographic) and farm tenure, income and perceived net benefit (financial resources). Overall, farm size was found to be the main driver affecting the uptake of PA technology (the larger the farm, the greater their intention to invest), with farmer's computer and technological skills the second most important factor. Survey data from Canadian farms was used in an empirical analysis of farmers' motivations and barriers to the adoption of PA technology. The Diffusion of Innovation (DOI) theory was used to explain the reasons behind variability in the adoption of an innovation (visibility, compatibility and trialibility), whilst the technology acceptance theory focussed on the perceived ease of use and usefulness of a PA technology (Aubert et al., 2012). One finding not commented upon previously within the scope of this literature review is that there exists a negative relationship between uptake of PA technology and voluntariness, suggesting that regulation might have a positive impact on uptake. This is direct contrast to the voluntary formation of environmental co-operatives, by farmers in Australia, Canada, the Netherlands and New Zealand, who were keen to protect the value of their farm assets and to avoid regulation (OECD, 1998). Two distinct benefits have been noted to be derived from PA technology, with 'win-win' potential (OECD, 2004), through enhanced productivity and performance and environmental sustainability. However, in order for these benefits to be fully exploited, there is a need for policy development and the provision of initiatives to foster support in the adoption of PA technology.

Farm Business Co-operation

Whilst there was a wealth of published literature relating to innovation at the farm level, the scope of literature relating solely to Farm Business co-operation was much more limited. However, there are a number of studies dealing with issues that traverse both innovation and co-operation and have therefore been referred to in both sections. The majority of published research articles focussed on formal co-operation on the scale of farmer co-operatives, co-production and networking, with extremely limited literature available on the more informal types of co-operation.

Definition of Co-operation

The Oxford English Dictionary defines co-operation as "the action or process of working together to the same end". An expansion of this is given in the Business Dictionary, which defines co-operation as a "voluntarily arrangement in which two or more entities engage in a mutually beneficial exchange instead of competing. Co-operation can happen where resources adequate for both parties exist or are created by their interaction".

Motivation and Barriers to Co-operation

Agricultural Innovation Systems

Agricultural Innovation Systems also play a pivotal role in the development of policies that encourage the establishment of flexible support systems (Klerkx et al., 2010). Where co-operation and co-ordination are limiting factors in the potential progression of an innovation system (Pascucci and de-Magistris, 2011), new ways of examining co-operation among individual farms to establish economies of scale can be illustrated by looking at Case Study approaches. One example in The Netherlands aimed to establish a formal pooling of land, labour and other resources to increase scale, by forming a joint venture (Sjalon), and thereby providing an alternative to the normal situation of individually owned family farms. The initial impetus began with the recognition by an individual farmer that his farm was too small to create a sustainable farming future for his son. The formation of a primary brainstorming group focussed on the idea of scale through the establishment of a collective farm with a clear division of tasks. The use of a facilitator to assist in developing the idea was the key component to the eventual success of the co-operation, leading to academic research and support from the Ministry of Agriculture, Nature and Food Quality (LNV). Despite a lengthy delay due to legal issues, the (Sjalon) group was eventually formed in 2008 as a limited liability company. This particular innovation network succeeded by reducing the number of financial, political and resource/competition uncertainties (Klerkx et al., 2010), whilst emphasising the key role of specialised consultants, namely innovation brokers and innovation champions.

Studies have also shown that innovation activity may be enhanced by, or even depend upon, co-operation with other actors involved in the innovation process, where co-operators are seen as 'external assets' (Adler and Shenbar, 1990, cited by Huggins and Hindle, 2010). Co-operation within an innovation system may be with scientific researchers, suppliers of new technologies and agricultural advisors, with wholesale purchasers and end customers, and through alliances and informal networking. All of these external links may play an important role in developing technological assets to maximise growth and performance (Huggins and Hindle, 2010).

Innovation Brokers

As discussed earlier in this literature review, successful innovation depends upon co-operation of several different actors. Scientific and policy literature suggests that there is an on-going need for intermediaries or 'brokers' to bridge the gap between them and the farmer. These gaps may exist as a result of cognitive distance between actors from different institutional backgrounds, leading to communication breakdown, information gaps regarding the benefits a potential co-operator may have to offer and managerial gaps where new technology or knowledge cannot be successfully implemented (Bessant and Rush, 1995, cited by Klerkx and Leeuwis, 2009). As user involvement within the innovation process grows, the establishment of connections between the demand side and the supply side highlights the importance of networking, with innovation brokers effectively fulfilling the role of network facilitators. Klerkx and Leeuwis' (2009) Dutch agricultural study categorised innovation brokers into a number of categories:

'innovation consultants', who connect individual farmers on both a regional and national scale, with, for example agricultural consultants and farm machinery representatives, as well as providing access to funding and policy information; 'brokers', whose aim is to encourage peer networks and whose function is to bring farmers together to exchange knowledge and experience at the interpersonal and group level; 'internet databases' aimed at providing knowledge and information for successful networking and boundary organisations, acting at policy, research, education and user level (Klerkx and Leeuwis, 2009). The use of innovation brokers does however carry a degree of risk, in that difficulties arise in justifying spending public money and also the danger that the innovation broker may be perceived as a 'hidden messenger' for the government. The study concluded that a higher level of cohesive policy, with clearer guidelines on; raising awareness, networking support and consultancy and also physical infrastructure and funding, would serve to enhance the effectiveness of innovation brokers within the agriculture sector. Oreszczyn et al. (2010), in their study on farmers perceptions of new technologies, and in particular GM crops, suggested that farmers learnt about innovative technologies and practices as part of a complex learning system, by drawing upon their own resources and experiences, as well as interacting with other farmers (in a network of practice) and with other actors in agricultural support systems (web of influencers). The study found that reliance upon their own experience was often inhibited by increasingly complex rules and regulations, whilst the advice from the web of influencers would benefit from cohesion within the agricultural framework, for example in the provision of government-sponsored intermediaries (Oreszczyn et al., 2010).

Innovation Co-production Support Initiatives (ICSIs)

Innovation is increasingly considered as a process of co-production (Hartwich and Negro, 2010; Jasanoff, 2004, cited by Klerkx and Nettle, 2013) where actors along a value chain interact, co-operate and co-ordinate their activities to generate new knowledge, technologies and practices for desired change. (Klerkx and Nettle, 2013). Comparative case study analysis was used to examine support initiatives for dairy sector innovation in the Netherlands and Australia; both countries dairy industries share common features, and most notably include a previously strong public agricultural science and extension system that has moved towards increased private provision and dairy sector funding of research through farmer levies. Consistent with the dairy industry in the UK, both countries have experienced increasing global demand for milk, a decline in farm numbers and increasing average herd size (Leeuwis, 2004), leading, by necessity, to considerable capital and investment in infrastructure and human input. Qualitative analysis was employed to assess the extent to which ICSIs help to bring together the different actors with a stake in dairy innovation. The study drew conclusions that innovation policies within the dairy sector needed to recognise that institutional support, adequate resources and clear guidance are required in the form of ICSIs, particularly in the adoption of new technologies (Klerkx & Nettle, 2013).

Farmer Networks

By definition, network structure consists of direct and indirect links between partners, where trust is a key determinant in the successful flow of information, technology and resource across that network (Gulati et al., 2000; Kakouris, 2010, cited by Huggins and Hindle, 2010). The ability to network; to identify mutually beneficial partnerships; to collaborate with other businesses; and to engage in technology transfer and knowledge sharing are all important factors in overcoming the barriers often associated with farm businesses (Huggins and Hindle, 2010).

As innovation becomes more collaborative, the number of businesses that share knowledge is steadily increasing and consequently, co-operation and networking are playing a more pivotal role in the process of innovation (NESTA, 2008; see Huggins and Hindle, 2010). Farmers' participation in social and commercial networks and

collaborative alliances has been identified as a key driver of innovative capacity. Alliances formed between farmers have been shown to increase scale of production in order to exploit market opportunities, to increase negotiating power and financial capacity, and to enhance diffusion of information to harness innovation in a challenging environment. Where adoption of innovative technologies requires high capital expenditure, co-operation also allows for investment in technologically advanced machinery (May et al., 2011).

Farmers' networks may also be an effective means to contribute to sustainable agriculture development, with network member learning from each other and from researchers and advisors, acting as negotiating partners and investing collectively (Oerlemans and Assouline, 2004). The way in which farmer groups are (self) managed is as important as their overall goal. Limitations in institutional support, lack of infrastructure, lack of technical support and coherent organisation may often act as barriers to the success of a network. The study of one such farmer network in The Netherlands (the Zeeuwse Vlegel Network) illustrates how management and collective learning issues and were confronted and lessons learned for the future development of farmer networks. The Dutch case study examined a farmer network set up to adopt sustainable agriculture practices by using an alternative strategy in wheat cultivation, combining low inputs (pesticides and fertiliser), lower yields, quality production and higher prices, with farmers also collectively control processing, distribution and sales of wheat. Factors that threatened the success of the network primarily revolved around a lack of coherence among members due to differences in perceptions and goals, with the nature of the network placing a high demand on the capacity and quality of the individual member. External barriers to the success of the network included conflicting regulation, lack of infrastructure and adequate technical support and such problems emphasised the importance of the role of facilitators and advisors. The study also highlighted differences between those members of the network that initiated its start-up and those who joined once the network was up and running, with the network founders displaying proactive character traits, whilst those joining later did so for reasons of improved price and the labour extensiveness of growing wheat (Oerlemans and Assouline, 2004).

Whilst networks have been shown to exist in a local and regional context, they also exist on an international scale. The European Dairy Farmers (EDF) association is an international network of economists, consultants and farmers working together, using survey data from the Thűnen Agricultural Institute in Germany, to assess development prospects for agriculture (EDF@www.dairyfarmer.net). Recent survey results have indicated that robotic milking systems are more widespread in countries where the hourly pay is greater than €20, for example Sweden and the Netherlands. Although investment costs for such technology are comparable across Europe, a key driver for the adoption of new dairy technology is its labour saving benefit and consequent positive impact on productivity. An additional factor, however, is likely to be the accessibility of technological support and professional advice, as two of the main milking technology companies are based in these two countries (Lassen, 2014).

Farmer Co-operation and Collaboration

Following the development of a new EU Dairy Package in December 2011, a facilitation programme for English dairy farmers, the Royal Association of British Dairy Farmers (RABDF) Foundation for Collaboration, has been set up with support from the RDPE and funded in part by the European Agricultural Fund for Rural Development. Although many dairy farmers are already collaborating, through membership of buying groups, discussion groups and producers organisations, the programme has been designed to help dairy farmers examine new ways of working together, in order to enhance farm business performance and provide a more stable and sustainable future.

The Lifetime Ewe Management program, introduced in Victoria, Australia in 2006, illustrates the success of farmer collaboration to enhance uptake of innovative management tools. Whilst numerous innovation adoption programs have attempted to increase the reproductive efficiency of sheep, there has been a reluctance to embrace a change in farming practices, primarily due to the complexity of the management practices required to implement such a strategy. In general terms, the more complex an innovation is to implement, the slower the rate of adoption (Trompf et al., 2011). Although theory suggests that new practices are more likely to be adopted by the most innovative producers (Rogers, 2003, cited by Kutter et al., 2011), farmers spanning the whole spectrum of innovativeness were successfully recruited onto the Lifetime Ewe Management programme, suggesting that farmers could perceive the immediate benefits of participation. Results from the study confirm the success of the program, with similarities recorded across all levels of innovativeness, as measured by the degree of change in productivity. The success of the program was attributed not only to the farmers' ability to change their attitude, expand their knowledge and improve their livestock management skills, but also in the use of qualified facilitators (Trompf et al., 2011).

Farmer-led initiatives, often voluntary in nature, can be illustrated by the formation of environmental co-operatives by farmers in Australia, Canada, the Netherlands and New Zealand, who were keen to protect the value of their farm assets and to avoid regulation (OECD, 1998). However, responses and perceived value varied depending upon the length of time the groups had been established.

Precision Agriculture Technology

Farmers' communication and co-operation strategies are known to play a key role in the successful adoption of Precision Agriculture (PA) (Kutter et al., 2011). Their qualitative survey of a select group of farmers in Germany and Denmark concluded that other farmers, agricultural technology firms and consultants, professional literature and agricultural trade shows all provided an importance source of information regarding PA technology, with IT a valuable tool, especially for younger farmers (Kutter et al., 2011). Joint investment of farmers in new technology varied between countries, with those from Germany less likely to co-invest than those in Denmark. High learning costs made it more likely for some German farmers to invest in one specialist piece of machinery, then to offer their services to other farmers. However, the potential for permanent sharing of installed differential GPS antennae, as well as developments in the compatibility of agricultural machinery are both likely to facilitate co-operation through joint investment in the future (Kutter et al., 2011). The use of contractors is a common feature of German agriculture, although demand focussed primarily on soil and yield mapping, with smaller farms facing financial barriers to investment, but still needing to reduce input costs. The idea that larger farms are likely to be more innovative (Rogers, 2003, cited by Kutter et al, 2011) is, in part, influenced by their co-operation strategy, which is directed more towards consultants and contractors. Participants in the survey also had expectations that contractors would need to adopt precision technologies in order to remain competitive, with machinery rings, contractors and specialised service providers able to exploit the benefits of precision technology more effectively than famers as individuals.

Agricultural Marketing Co-operatives

Farmers began to co-operate in order to benefit from economies of scale and risk management, as a means of improving performance. The key objectives of any co-operative are to maximise return and ensure continuity (Soboh et al., 2009). Co-operatives display a wide variation in structure, management and goals and have a dual purpose, i.e. to deal with competitive markets and to satisfy the needs of its members. Their overriding success depends whether they can provide their members with more

than they would achieve if acting independently, mainly in terms of profitability, but also in providing non-economic benefits such as transfer of knowledge and expertise. The scale and subsequent strength of agricultural marketing co-operatives allows them not only to maximise output prices, but to minimise input price fluctuations too. Traditionally, agricultural marketing co-operatives operated on a membership only, "one member, one vote" basis (Chaddad and Cook, 2004, cited by Soboh et al, 2009) and whose source of capital was primarily from up-front investments and member contributions. However, the nature of these co-operatives has evolved in the last decade, where organisational innovations, such as new generation co-operatives, partnerships, member-investor co-operatives and equity-seeking joint ventures are being adopted in order to keep up with consolidation in the agribusiness and food industries (Soboh, et al., 2009).

New Generation (NG) Co-operatives

A new form of co-operative was developed in America in 2005 through joint funding provided by the US Department of Agriculture and the US Department of Energy (Downing et al., 2005). New Generation co-operatives in agriculture focus on value-added characteristics and processing rather than raw commodities, with the main advantage being that farmer-producers have a collective strength and stability. In the US, Minnesota and North Dakota were seen to be the leaders in the development of co-operatives and this development appeared to have been generated by the farmers need for problem solving related to market development. The New Generation (NG) co-operatives proved to have a positive impact on the development of renewable energy and agricultural enterprises, where advantages appeared to show that farmer-producers were able to react more quickly to opportunities and problems that arose (Downing et al., 2005). The key success in developing these new generation co-operatives was a result of their ability to secure financing, to successfully navigate the process of formation of a co-op and the assembling of a group of dedicated and committed producers with a motivated leader (Downing et al., 2005).

Summary

The primary objective of the literature review was to identify the key factors driving innovation and cooperation in agriculture. Innovations with a clear financial benefit or those offering cost effective changes to a business, particularly via labour reducing approaches, were found to be factors with strong innovation-enabling characteristics. Moreover, where the farm business has access to external or internal funds, access to advisers, training or information, and where the operator of the farm business has a greater level of educational attainment, uptake of innovation was more likely to occur. Other factors associated with innovation uptake included larger farm or business size, younger farmers, farmers who were willing to take risks and those with access to farmer and social networks, or information and communications technology (ICT). Moreover, the degree to which an innovation fits or aligns with current practice, and innovations that are defined as 'pull' factors from the industry, were also found to be innovation-enabling. Other aspects found to affect innovation included farm tenure and the intensity of agricultural production.

Aspects of cooperation that provided demonstrable financial benefits, economies of scale or efficiency improvements, for example via labour and machinery pooling, were perceived in a positive way by farmers. Moreover, where farmers were involved in discussion groups, or had strong social cohesion networks within a local area, such factors were also found to be positive drivers of cooperation. The presence of advisers and 'innovation brokers', greater compatibility of labour and machinery technology between parties, and the presence of interactions along the marketing or value chain, were also key in the successful adoption of co-operation. Conversely, limitations in institutional support were noted to be a constraining factor towards cooperation.

Aspects of group cohesion and management, with inaugural members of a cooperative group being more motivationally driven than those joining a group later, with group laggards typically seeking to achieve financial benefit as the sole or primary reason for their cooperation. Additionally, aspects of the need for clear leadership and decision making were also highlighted as a cooperation enabling factor.

Appendix 2: Letter of Invitation

Rural Business Research Unit
Tel: 01904 772219 Fax 01904 772209

Ref:

Date

Name
Address

Dear

Study on Farmer Cooperation and Uptake of Technology

We are currently engaged in a research project looking at different aspects of the performance of farms in the Farm Business Survey. We are particularly interested in the connection between farm performance and other factors such as the approach to innovative techniques, adoption of new technology and the degree to which farmers cooperate together in different aspects of their farming activity. From the Farm Business Survey, we have identified a small group of farms that we would like to study further for this project.

Your farm has been identified as one that we would like to look at in greater detail and I am now writing to ask if you would be willing to help in this study. We would like you to take part in a face to face interview which would probably take about an hour or so to complete. The focus of the questions is based on these topics of the use of technology, innovative approaches and attitude towards cooperation. No farms or farmers will be identified in any published results.

For consistency, all the interviews will be undertaken by the same person(s). My colleague, [insert name] will contact you shortly, to ask if you are willing to help and to arrange a convenient date and time to come and visit you. We would hope to complete these interviews in the next month or so.

We do appreciate your cooperation in the Farm Business Survey and hope you will also be willing to help in this study. If you have any questions please contact me on 01904 772218.

Yours sincerely

M R Lewis
Head of Rural Business Research Unit

Appendix 3: Semi-Structured Interview Format

Short introduction text.

Defra is interested in a more competitive and sustainable farming sector where farmers work together and also adapt to meet new challenges. The purpose of this discussion is to learn from your experiences and examine any links between farm business strategies for innovation, early adoption and farm performance, including adoption of, and barriers to, the uptake of innovative approaches and new technology. Understanding links between approaches to innovation and cooperation and farm level performance is important in the context of developing future policies to facilitate a resilient and competitive agricultural sector.

Semi-Structured Interview Format

Centre		Code number	
Farm type		Date	

Performance group		Length of interview	

Section 1. Background/Management structure

1. How long farming at current location?

2. History prior to moving here, including other employment.

3. Year of Birth

4. M/F

5. Are you sole decision maker? Y / N

6. If not sole decision maker, who else is involved?

7. Highest educational qualification: (give qualification and subject details) this to cover all individuals with some input into decision making on the farm i.e. spouse, son / daughter etc.

8. How long managing the business?

9. Describe decision making process – who else is involved and how are decisions made.

10. Do you use advisors or consultants? If so, what for.

Section 2. Farm Business Cooperation

11. Do you co-operate in any way with other farmers?

12. What do you consider are the barriers to co-operating?

13. Please outline any informal arrangements

14. Please outline any formal arrangements

15. Do you carry out any contracting for other farmers or use contractors yourself?

16. Please explain how farmer cooperation fits with your approach to farming and how it affects your business.

17. Has your level of farmer cooperation increased or decreased over the last 3 years?

18. What do you think has been the reason(s)?

19. Do you expect to see any changes in the future to the level of your cooperation with other farmers?

20. What single piece of advice would you give to other farmers thinking about starting or increasing cooperation?

Section 3. Innovation and Technology

21. What is your attitude to innovation?

22. Is there anything you feel you should be doing differently, more of, less of?

23. Have you adopted an innovative approach to any part of your farm business practice in the last 3 years? If so what has that been?

24. What has been the impact on your business?

25. What was the motivation to adopt this innovative approach and where did the idea come from?

26. Was this part of a business strategy?

27. Were there any barriers to adoption?

28. Are you planning to adopt any innovative practices or new technology in the next 12 months?

29. Are there any barriers to your adoption of specific innovative practices?

30. How do you keep up to date with technical developments? (for all people working on the farm) e.g. training, attending sector events, newsletters etc.

31. What is the business investment strategy for machinery and equipment?

32. Have you made any changes to the way you farm using different types of machinery in the last 3 years?

33. What is your approach to training and qualifications for both yourself and your staff?

34. Are you a member of farmer discussion or communication groups or similar?

35. Do you use professional advisors to help with decisions on adopting innovative practices or new cooperation venture e.g. accountants, legal advisors, vets, agronomists etc

36. What single piece of advice would you give to other farmers seeking to adopt more innovative practices e.g. new technology.

Section 4. Goals and Objectives

37. What are your key objectives, goals or aims in running the farm business?

38. Do you plan any major changes in the next 5 years?

39. Do you see any barriers to this change?

40. What do you think the prospects are for your farm business?

41. Is there a clear succession plan for managing the business? How does this impact on the business and your approach?

Other Respondent Comments:

Thank you. Really appreciate your time etc.

OFFICE USE:
Researcher comments: