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TECHNICAL REPORT

Translational Research and Knowledge in agriculture and food production

Watu Wamae, Pauline Goyal-Rutsaert, Molly Morgan Jones, Siobhán Ní Chonaill, Joyce Tait, Joanna Chataway

Prepared for the BBSRC and Defra

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Preface

This report, prepared for and funded by the Biotechnology and Biological Sciences Research Council (BBSRC) and the Department for Environment, Food and Rural Affairs (Defra), presents the results of an analysis of translational research and knowledge exchange in the UK agricultural sector. The aim of this study was to better understand how to assist the effective translation of research outcomes to practical application in the complex and diverse agriculture and food value chain.

In this report we present a methodological framework for analysing translational research and knowledge exchange; its application to the UK wheat value chain and development of an evidence base; along with an analysis of the modes of translational research and knowledge exchange, the motivations to engage in these activities, and the barriers and enablers. The research project was undertaken between September 2010 and April 2011, with the data collection occurring between October 2010 and January 2011.

This report should be of interest to government officials managing investment programs related to translational research and knowledge exchange, policymakers in the domain of technology policy, researchers studying the field of science and technology, and research and development centres in private companies.

The research was lead by RAND Europe with support from Joyce Tait from the ESRC INNOGEN centre at Edinburgh University, Home Grown Cereals Authority and Campden-BRI.

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Contents

Table of figures

Table of tables

Table of boxes

List of abbreviations

BBSRC	Biotechnology and Biological Sciences Research Council
Bioscience KTN	Biosciences Knowledge Transfer Network
BIS	Department for Business, Innovation and Skills
BPEX	British Pig Executive
CAP	Common Agricultural Policy
CIMMYT	International Maize and Wheat Improvement Centre
CLAHRC	Collaboration for Leadership in Applied Health Research and Care
CRIC	Crop Improvement Research Club
DARD	Department of Agriculture and Rural Development
Defra	Department for Environment, Food and Rural Affairs
Dfid	Department for International Development
DH	Department of Health
EPSRC	Engineering and Physical Sciences Research Council
ERA-NETS	European Research Area Networks
ESRC	Economic and Social Research Council
EU	European Union
FAO	Food Agriculture Organisation
FERA	Food and Environment Research Agency
GMO	genetically modified organism
HEFCE	Higher Education Funding Council for England
HEFCW	Higher Education Funding Council for Wales
HGCA	Home Grown Cereal(s) Authority
KT	knowledge transfer
KTN	Knowledge Transfer Network

MALNA	Managing late N applications
MRC	Medical Research Council
NABIM	National Association of British and Irish Millers
NERC	Natural Environment Research Council
NIR	near-infrared
NGO	non-governmental organisation
NIAB-TAG	National Institute of Agricultural Botany and TAG Consulting
OECD	Organisation for Economic Co-operation and Development
REF	Research Excellence Framework
RTC	Research and Technology Club
SAF IP	Sustainable Agriculture and Food Innovation Platform
SFC	Scottish Funding Council
TSB	Technology Strategy Board
UK	United Kingdom
WAG	Welsh Assembly Government
WGIN	Wheat Genetic Improvement Network

Summary

This report considers how translational research and knowledge exchange can be enhanced throughout the food and agricultural value chain so that best use is made of public and private investment in research and knowledge generation. The project's aims were:

- To generate a robust, generic and transferable methodology for examining translational research and knowledge exchange across an entire value chain;
- To apply and validate this methodology to deliver a robust evidence base for translational research and knowledge exchange in the wheat value chain in the UK;
- To outline mechanisms for maintaining the evidence bases.

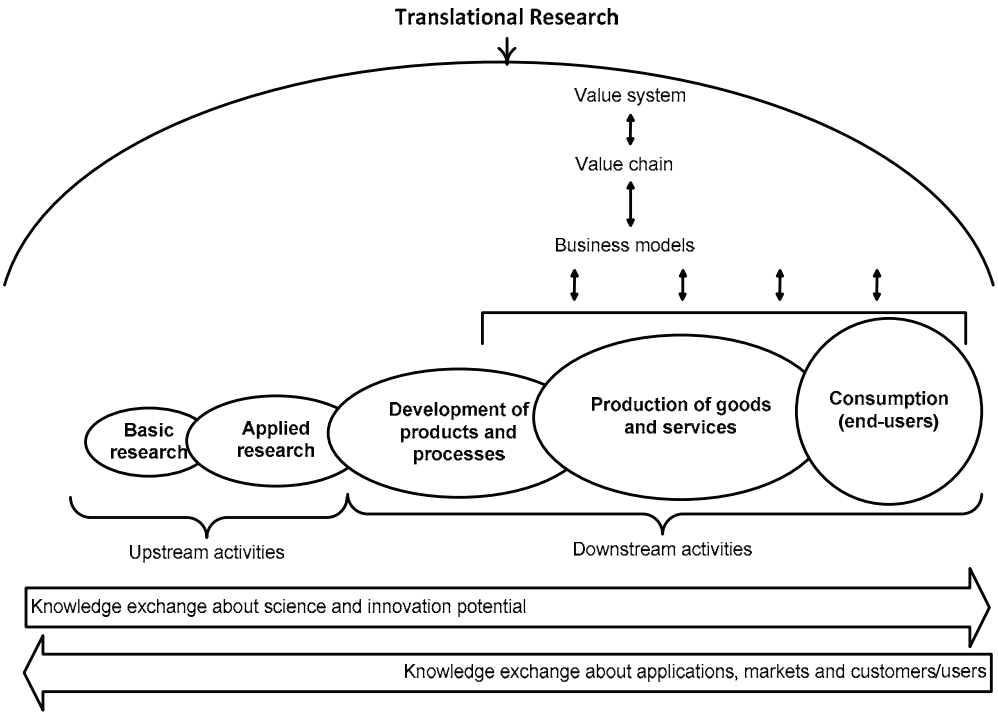
The wheat value chain, chosen as the test case for development of the methodology is currently perceived to be under-performing: despite considerable investment in basic science, wheat production has remained relatively static in terms of both quantity and quality.

Approach and Methodology

The methodology developed for this project built on recent initiatives related to supporting innovation in life sciences in the UK Technology Strategy Board, adopting the following definitions:

> *Translational Research* - the new scientific methods and technologies, interdisciplinary approaches, and collaborative institutional arrangements being developed to narrow the gap between basic science and its application to product and process innovation.
>
> *Knowledge Exchange* - the multi-directional flow of information of all kinds that is required as a basis for decision making in the translational research process.
>
> *Value chain* - the range of activities required to bring a product or service from conception, through the different phases of production, to delivery to consumers.
>
> *Value system* – the wider system within which the value chain operates including: policy and regulation, finance and markets, and public and stakeholder perspectives.

The following diagram outlines our conceptual approach to the study and indicates interactions relevant to our understanding of translational research and knowledge exchange.



Source: RAND Europe and INNOGEN

Figure 1 Conceptual framework for translational research and knowledge exchange in agriculture and food

The project distinguished four actor roles within the value chain: funders of knowledge generation; knowledge producers; knowledge intermediaries; and knowledge users. In most cases actors took on more than one of these roles in contributing to different aspects of the translation process. In the wheat value chain, knowledge about innovation potential and scientific expertise on how to realise that potential, along with knowledge about applications, markets and consumers' preferences, flows among the four categories of actors through multiple channels and feedback loops. The methodology developed here was designed to chart these interactions and knowledge flows, to identify successful examples of knowledge exchange and to identify blockages and pinch points that inhibit the translational research process.

The project had three key components: literature review, a survey of key actors and a validation workshop.

The literature review provided an evidence base of all relevant actors, their engagement in wheat translational research and all relevant fields of knowledge. Based on these data, two matrices were developed (i) an actor/activities matrix to identify 'who does what' and (ii) an actor/actor matrix to identify 'who engages with whom' in the context of wheat translational research. The project also developed a method for tracking the sequence of interaction nodes over time, where knowledge of different types is exchanged among actors at various points along a value chain.

A survey of key actors (knowledge producers, knowledge intermediaries and knowledge users) was undertaken to enrich this evidence base. Interviewees were asked questions about the importance of different factors in successful translational research, modes of

knowledge exchange and translational research, motivations to engage in these activities, and barriers and enablers of translational research.

The validation workshops brought together additional key actors in all categories to discuss the results from the literature review and the survey, and to contribute new insights to their interpretation.

Outcomes of research

The following were among the main outcomes from these analyses:

- The actor/activities and actor/actor matrices offer an effective means to summarise and present clearly the range of knowledge exchange activities that contribute to a value chain. They also usefully highlight potential gaps in the translational research process that can be explored further with a view to improvement.
- The matrices showed a great deal of translational research activity, including at the near-market end of the wheat value chain. Translational activity by knowledge producers was captured well by the literature review, but interviews more effectively captured information about the less publicised activities among knowledge intermediaries and knowledge users.
- For knowledge exchange, a high value was placed on face-to-face interaction, particularly by knowledge intermediaries and users, reflecting the often tacit nature of the knowledge required for effective translation. On the other hand, for knowledge producers, conferences were the preferred mode of knowledge exchange.
- Price volatility in recent years was seen as a major factor inhibiting translational research in the wheat value chain, making it difficult to assess the economic benefit of uptake of new products and processes.
- The complexity of the wheat value chain, which is long and feeds into many products, was considered a challenge to translational research.
- Other important barriers to knowledge exchange identified by interviewees were: recognition of the need for collaboration but nervousness about losing commercial advantage, particularly at the near-market end of the value chain; a perceived mis-alignment of interests between knowledge producers and knowledge users; the time and costs required to engage in translational research and the time required for a research programme to generate user-relevant outcomes; policy and regulatory barriers inhibiting basic research and its translation to products and processes; eligibility criteria for public funding of research that (in some cases) give priority to scientific excellence rather than translational opportunities.
- Important enablers of translational research were seen to be: the development of fora to facilitate knowledge exchange and to enable development of a synthesis of existing knowledge on specific topics; involving key actors and targeting end users across the value chain in a more systematic and informed manner; the effective use of policy to drive innovation and knowledge exchange based on a translational approach as outlined here (until recently many policies have advocated reduced emphasis on technology and productivity in farming systems).

Translational research and knowledge exchange in practice

Three examples of translational research in wheat-related areas provided further insights into wheat-related translational research. They draw attention to the difficulties of bringing cohesion to a fragmented value chain and of convincing farmers that investment could bring economic benefits.

- Stimulated by EU legislation imposing minimum standards for mycotoxin contamination of flour, the HGCA promoted the integrated development of risk protocols along with supporting equipment. The clear focus, along with effective investment in knowledge exchange led to uptake of the approach by farmers and millers.
- A project based on genetic markers, led by Campden-BRI, developed methods to measure the processing performance of wheat and to determine the genetic control of baking quality. However, no public funding was allocated to build on these findings and although knowledge generation was successful, its translation has proved more uncertain.
- Using high quality pig and poultry feed increases the quality of the animals obtained but there are few incentives for grain growers to focus on the quality of the feed they produce. This gap in the middle of the value chain could be addressed using equipment developed by the HGCA, but the technique has not been validated for on-farm use and it is expensive. As a result, growers are not getting a benefit from producing higher quality grain although feed producers are using the technology.

Conclusions

This report has offered fresh insights into the conceptual frameworks and methodologies that can be deployed to investigate and promote translational research and knowledge exchange in agriculture and food production in general and specifically in the UK wheat sector. In applying the methodology the report demonstrates the value of the matrix-based data gathering tool as an evidence base on core components of knowledge exchange and translational research. This could be expanded and maintained as an on-line resource to enable policy makers to chart changes in patterns of translational research over the coming years.

This evidence base will inevitably need to be supplemented by information more directly related to practitioner experiences. The interview programme and workshop in this project enriched the insights from the literature review and contributed to understanding of the potential role of translational research in the wheat value chain. This approach would also be essential in the wider implementation of translational research in the agriculture and food contexts.

Translational research in the health care area is providing powerful insights to address many of the kinds of question raised in this report. This project has demonstrated how a translational research approach could be adapted for use in the agricultural and food sectors and how it could deliver benefits that are of value to policy makers.

Acknowledgements

We would like to thank all interviewees and workshop participants for the time and thought given to this work. We would also like to thank the BBSRC/Defra steering committee for their guidance and discussion.

We particularly acknowledge the contributions of Campden BRI who gave valuable input throughout the study, and HGCA who kindly provided the team with insights drawing on their industry expertise and knowledge.

This report has been authored by the study team from RAND Europe and Joyce Tait from the ESRC INNOGEN centre, Edinburgh University, and we gratefully acknowledge the inputs from the quality assurance reviews from Peter Burge and Desiree van Welsum. Any errors or omissions herein remain the responsibility of RAND Europe.

CHAPTER 1 Introduction

1.1 Translational research and knowledge exchange in the agriculture and food value chain

A number of high profile, recent academic and UK government reports draw attention to the huge efforts needed to address food production challenges in the coming years (UK Government Office for Science, 2011 and 2010; HM Government, 2010)[1]. At the same time pressure mounts to address environmental issues and meet consumer demand for higher quality and healthier food at lower prices. In an attempt to address these multiple concerns the UK government has adopted a more integrated and holistic approach to agricultural and food policy (HM Government, 2010). In this context it is timely and relevant to look at how translational research and knowledge exchange can be enhanced throughout the food and agricultural value chain so that best use is made of public and private investment in research and knowledge generation. Changes in the way that research and extension work are funded in the UK agricultural and food sector, with an increased role for the private sector and a reduced role for public sector actors, add to the reasons for taking a fresh look at translational research and knowledge exchange in this area.

1.2 The aim of this study

The aim of this study is to enable the Biotechnology and Biological Sciences Research Council (BBSRC) and the Department for Environment, Food and Rural Affairs (Defra) to better understand how to assist the effective translation of research outcomes to practical application in the complex and diverse agriculture and food value chain.

Translational research and knowledge exchange have been widely explored in health but less so in agriculture and food. A literature search undertaken as part of this study reveals that there are significantly more peer-reviewed publications using the words 'translational research' in health than in agriculture or the wheat sector[2]. This project, then, seeks to generate tools and insights into translational research and knowledge exchange activities in the wheat sector as a model that can then be applied to other agriculture and food production contexts.

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[1] The North American and European Sub-report of International Assessment of Agricultural Science, Technology and Development (IAASTD) provides a detailed picture of changes in North America and Europe over the last 50 years.

[2] See Appendix A for details.

This study seeks to meet three key objectives:

- To generate a robust, generic and transferable methodology for examining translational research and knowledge exchange across an entire value chain
- To apply and validate this methodology to deliver a robust evidence base for translational research and knowledge exchange in the wheat value chain in the UK
- To outline mechanisms for maintaining the evidence bases

1.3 Translational research and knowledge exchange in the UK wheat value system

Box 1-1presents the diversity of the wheat value chain and some major factors influencing it. The wheat value chain and the value system within which it operates is complex[3].

The complexities of wheat production

Around the world, in Europe and the UK, wheat value chains are highly diverse, complicated and often fragmented. There are a number of reasons behind this (in no particular order):

- Being a commodity market, end users are looking for competitive pricing
- Variation in annual production, particularly due to weather, means that competitiveness of the market itself varies from year to year and that producers and exporters have variable levels of competitiveness within that market
- Varying weather conditions also mean that the quality of crops is variable, so farmers cannot guarantee the consistency of supply required by consumers

Within the overall wheat market there are different quality grades, each with unique supply and demand conditions. For the animal feed sector, competitiveness on price is key and substitution from other feed grains can occur. Feed wheat is a pure commodity product with little potential to add value and so little incentive for vertically integrated value chains.

For the food sector, quality is the dominant driver of the value chain. Processors need consistent quality characteristics And given the fragmented nature of the value chain the commodity can move to the most profitable end user.

For biofuels, in the longer term, sustainability reporting is likely to become more important, leading to less fragmentation and greater transparency.

Source: RAND Europe

Box 1-1 Complexities of wheat production

Indeed the value chain is made up of several sub-value chains, for example wheat for human consumption, wheat for animal feed, and wheat for bio-fuel. Thus translational research and knowledge exchange in the wheat value chain are subject to influences from factors impacting on the overall value chain and from factors that impact differentially on the sub-value chains.

The wheat sector also operates within a particularly volatile economic environment as described in the following box.

[3] See Appendix H - Figure H-1 shows how actors in the UK agri-food sector are organised.

Price volatility

In the last five years, global wheat prices have entered into an unprecedented period of volatility, with spot UK feed wheat trading in a range of £60/t to £210/t. This has had clear impacts on farm profitability and processor raw material costs. Price drivers have largely been global as UK production only accounts for 2.5% of world total. The year 2007 saw the first major period of volatility following several years of low prices that had offered no incentive for farmers to produce more wheat even though global demand had been steadily increasing. The net-impact of this was degradation in global wheat stocks.

In addition to being used for feeding people, wheat is also an important animal feed grain which links wheat prices to one of the world's most volatile grains (maize). If wheat is perceived to be cheap relative to maize, more will be used and vice versa. The high prices of 2007 fuelled an increase in global production, producing a record crop leading to depressed markets in 2008. In 2010/11 key weather events impacted both wheat and maize availability fuelling further price volatility.

Source: RAND Europe

Box 1-2 Price volatility

Price volatility may be a disincentive to wheat production but as the overall price of wheat has risen dramatically over the last five years it may also have stimulated investment. This context poses additional challenges for farmers and other actors across the wheat value chain in making decisions about the benefits of engaging in translational research and knowledge exchange.

1.4 Outputs of the study

There are three main outputs of this study.

First, this report offers fresh insights into the conceptual frameworks and methodologies that can be deployed to investigate and promote translational research and knowledge exchange in agriculture and food production in general and particularly in the UK wheat sector.

Second, the matrix-based data gathering tool and the matrices presented here offer detailed evidence about core components of translational research including basic and applied collaborative, near market and in-house research. The tool is designed to enable policy makers to chart changes in patterns of translational research over the coming years.

The third output is less tangible but no less important. In the course of the study we have talked with a wide variety of actors who have interests in developing translational research and knowledge exchange in the agriculture and food sector. At the practitioner workshop for this project, it was observed that development and implementation of the concepts of translational research and knowledge exchange have progressed strongly in the area of health-related innovation and this project is an important contribution to improving these processes for agriculture and food production.

CHAPTER 2 Definitions, conceptual framework and methodological approach

This study investigated translational research and knowledge exchange in the context of the agriculture and food value chain. The focus of empirical data collection was wheat.

The following section defines the core concepts used in this study, based on experience of their application in a Technology Strategy Board funded project in the ESRC Innogen Centre under the Direction of Joyce Tait[4]. It also explains the framework used to guide data and evidence gathering.

2.1 Definitions and explanations

The term '*Translational Research*' is used here to describe the new scientific methods and technologies, interdisciplinary approaches, and collaborative institutional arrangements being developed to narrow the gap between basic science and its application to product and process innovation[5]. Translational research encompasses scientific and technical, market and policy signals that arise from basic research to final consumers.

'*Knowledge Exchange*' describes the multi-directional flow of information of all kinds that is required as a basis for decision making in the translational research process.

A '*value chain*' refers to the range of activities required to bring a product or service from conception, through the different phases of production, to delivery to consumers. Each of these activities potentially creates or adds value, although some may involve a net cost (e.g. regulatory compliance) and some may add considerably more value than others. For instance, harvesting wheat may not add as much value as processing or baking. The agri-food value chain distinguishes key segments each involving different sets of actors, such as inputs, farm production, harvesting and distribution, industrial processing (first and second processors), retail and catering, and final consumption. The concept of a value chain aids understanding of the factors that drive and facilitate improvements in products

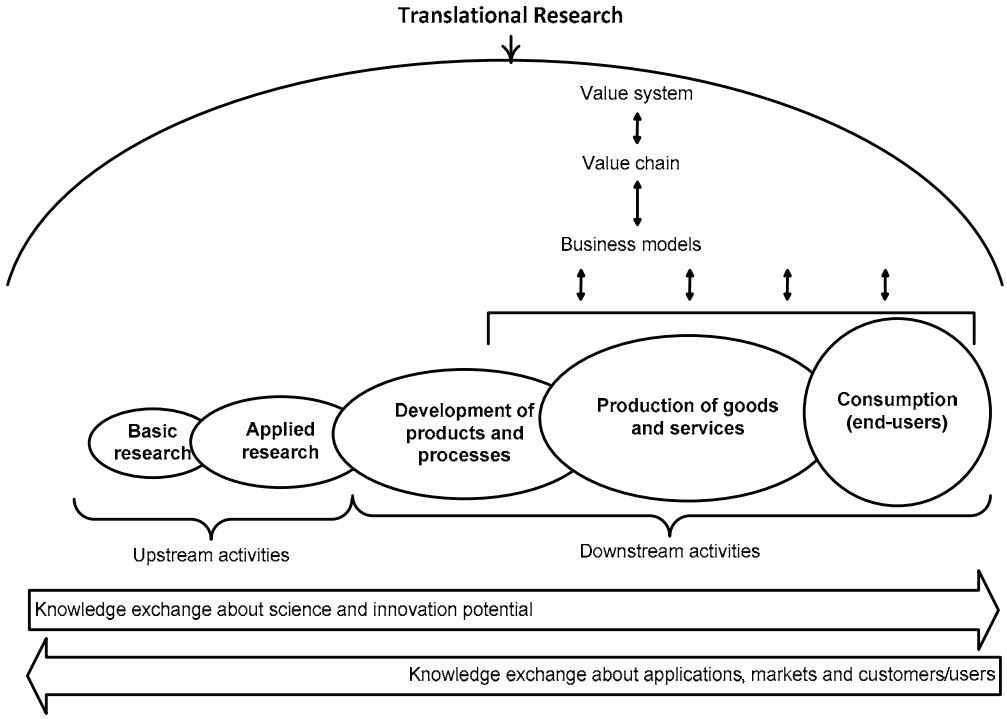
[4] TSB realise project, "Business Models and value systems for regenerative medicine therapies", 2010-2011.

[5] Some definitions of translational research conceptualise this type of activity as occupying a particular compartment in a value chain. Although translational research bridges a gap between academic research and focused commercial application, a key aspect of successful translational research lies in its ability to translate basic and scientific and technical properties into products that enjoy high market demand.

and process, helping to identify where there are innovative opportunities to add further value. In this report we apply the concept of value chain to wheat.

2.2 R&D, translational research and knowledge exchange

Translational research covers a range of activities from basic science at one end of the spectrum through to end-use or application. Some activities are mainly concerned with the creation of new ideas while others target the transformation of these ideas into novel products and processes. 'Research' plays a more significant role in upstream activities and 'development' plays a more important role in downstream activities. Both upstream and downstream activities generate knowledge of a range of different kinds that is critical for translational research, and the ease with which this knowledge is exchanged therefore influences the effectiveness of translational research. The following diagram represents these relationships[6]:



Source: RAND Europe and INNOGEN[7]

Figure 2-1 Conceptual framework for translational research and knowledge exchange in agriculture and food

[6] The terms basic and applied research are borrowed from the Frascati Manual. However, they used here in a broad sense to refer to the basic research that takes place in upstream activities And the development that takes place downstream. Research and development together are much broader than basic and applied research; they include, for example, near market testing. In addition, the distinction between basic and applied research is often subjective. The aim of these distinctions is to understand how different activities contribute to translational research rather than to provide demarcations of different research activities.

[7] The section of Figure 2-1 illustrating upstream and downstream activities is adopted from Bell (2007), who bears no responsibility for any modifications.

Figure 2-1Figure 2-1 summarises the conceptual framework developed for the analysis of translational research and knowledge exchange. The diagram divides upstream and downstream activities and shows a dynamic relationship between *business models* (the way firms organise themselves and undertake business), *sectoral value chains* (the organisation of markets and organisations relating to specific sectors such as agri-food in general or wheat more narrowly) and *broader value systems* that incorporate policy, regulation and markets, and other factors that may encourage or constrain innovation (Chataway *et al.*, 2004). The arrows at the bottom of the diagram show how knowledge exchange flows across activities to bring science and technology to product development on the one hand and consumer and market knowledge back to earlier stages on product development on the other hand.

The model stresses the systemic nature of translational research and knowledge exchange incorporating interactions across the value chain and value system. Knowledge exchange generates feedback loops in translational research and contributes to the improvement of products and processes; knowledge exchange facilitates the process of adding value to products and processes. Value chains integrate production, marketing, and consumption issues to achieve this added value and the overall value system shapes how value chains are organised.

Numerous enablers and barriers at all levels can impact on the rate and direction of translational research and knowledge exchange. These may include market failures or they may be related to the way that organisations function within a sector (Chataway *et al.*, 2006), influenced by institutional and cultural norms. Indeed all of these factors seem relevant to this case study of wheat.

Knowledge exchange and indeed knowledge generation can thus take place at many points along this chain, from fundamental scientific discovery to knowledge about manufacturing processes or markets. Effective translational research requires integration across all relevant actors and activities, as depicted by the over-arching boundary in Figure 2-1.

2.3 Methodological approach

In developing a methodology, we adopted an approach that could generate substantive empirical data about translational research and knowledge exchange and could be transferred to other sectors. Thus the data gathered for this study relates to wheat, but the methodology is transferable to other sectors.

The following research was undertaken:

- *A literature review,* exploring literature on translational research and knowledge exchange in agriculture in general but focusing predominantly on the wheat sector.
- *Development of matrices describing actor/activities and actor/actor relationships in translational research and knowledge exchange.* There is no comprehensive understanding of where translational research activities take place in the wheat sector and what knowledge is, or needs to be, exchanged across the components of the overall system described in the above sections. For example, near market

testing (research that is focused on aligning new or improved products and processes to the needs and preferences of end-users) is critical to ensuring the successful uptake of new or improved products and processes by end-users and even where these address a particular challenge, or add new value, they will fail to achieve the potential benefits if they are not widely adopted by end-users. We compiled evidence and data about where and between whom different types of translational research seem to be taking place across the wheat value chain.

- *Interviews.* We interviewed 45 people working across the wheat value chain. Details of interviewees can be found in Appendix B. We selected interviewees working in a broad range of translational research and knowledge exchange activities across the wheat value chain to capture the different perspectives of all relevant stakeholders. The respondents were experts covering all relevant aspects of wheat production and able to provide valid insights into the nature of translational research and knowledge exchange.
- *Workshop.* We held a validation workshop to which we invited participants from across the wheat value chain, (who had not been interviewed). They were asked to engage in discussion about all aspects of the work for this project.

2.4 Development of a basic model of translational research and knowledge exchange in a value chain

Value can be generated at any point along the value chain as it progresses from basic research towards applications in new processes and products. The more novel the basic knowledge at the start of the translation process, the greater the uncertainty of the outcomes, with a potential for surprisingly generous value creation, but also the chance of meeting one or more unexpected barriers, particularly in heavily regulated areas. The potential to generate value for those who are developing the new processes and products usually seems clearer towards the end of the value chain, but failure to think far enough ahead from the beginning of the value chain can result in very costly downstream failures. The benefit of the value chain approach is that it helps actors to predict and avoid these downstream difficulties and to deliver value more often and more effectively, and generate economic and social benefits.

In developing the methodology to examine translational research and knowledge exchange in a value chain, we set out a basic model to examine the factors influencing translational research and knowledge exchange decisions at the different points in the value system.

2.5 Types of actors

We distinguished four different types and roles of actors within the value chain and used these categories to structure our work on matrices and in selecting interviewees, making sure that we captured evidence and data from all four categories.

- *Funders of knowledge generation.* These are the agents (organisations or individuals) funding knowledge generation. We distinguish between funders in the public, private and third sectors on the basis that their motivations and modes of funding

are likely to be different and may lead to different types of knowledge outcome and also of knowledge exchange and translational research. Examples include BBSRC, the Bill and Melinda Gates Foundation, and Syngenta[8].

- *Knowledge producers*. These are the actors (organisations or individuals) who receive funding to carry out research. As noted above, public, private and third sector sources are likely to fund different types of knowledge producer and to generate different types of knowledge. Knowledge producers include universities, public and private sector research organisations and private sector companies with in-house research facilities.
- *Knowledge intermediaries*. These are the actors (organisations or individuals) who transfer or 'exchange' knowledge among producers and users. In so doing, they help knowledge users to improve products and processes and they also feedback information to knowledge producers, helping to contribute to more targeted knowledge outputs. Examples of knowledge intermediaries include consultancy companies, levy boards, farm advisers and farmers.
- *Knowledge users.* Knowledge users assimilate knowledge to produce innovative products and processes, leading to value creation. They can be active at any point along the value chain, integrating new knowledge into products and processes. Examples include plant breeders, farmers, equipment manufacturers, food processors and agri-business companies.

The above four categories apply to roles rather than specific actors. Any actor involved in the value system may be required to shift from one role to another at different stages in the translational research process. For example, an actor in a private firm may be a funder, producer and user of knowledge, depending on the context. Most individual actors will specialise in one particular role, but take on a different role when required to achieve effective research translation.

2.6 Conclusions

At the heart of our approach to this study is a focus on the interactions among the different actors in the value chains. Observation of how and when actors interact with each other and in which research fields should enable us to understand how knowledge evolves in the value system, from an initial idea to an application as product or process.

The methodology starts from general premises about value chains, knowledge exchange and translational research, supplemented by lists of relevant actors and fields of research, along with factors driving translational research and knowledge exchange decisions. Therefore, it allows for the characteristics of any sector to be taken into account and therefore can be widely applied to other fields and sectors beyond innovative wheat development.

[8] Syngenta takes multiple roles including funding knowledge generation as well as producing and using it.

CHAPTER 3 Using data on actors and activities to capture translational research in the wheat value chain

Upstream activities are important sources of the knowledge that is exchanged in downstream activities and our work on an actor/activities matrix has captured information about the actors engaged in translational research and knowledge exchange in the UK wheat sector. We developed a matrix that showed actor/actor interactions and revealed patterns of knowledge exchange among different types of actors across the wheat value chain. Evidence for this work comes from grey literature[9], websites and interviews.

3.1 Translational research and knowledge exchange in the wheat value chain

The conceptual framework for translational research and knowledge exchange, described in Section 2.2 and Figure 2-1, provides us with a starting point for the identification of key components in wheat translational research. This contributes to understanding the nature of research activities that occur in the wheat value chain and sheds light on how knowledge is exchanged throughout this value chain.

Figure 3-1 summarises translational research processes for the case of wheat. The different components are presented in broad categories, including new ideas arising from basic science that have been identified as having translational research potential. These different components enable the identification of the actors that comprise them based on the activities undertaken[10]. We have focused on three potential end uses for wheat (food, animal feed and biofuels), that have widely varying characteristics within their respective

[9] In this report, grey literature refers to a body of written material that cannot be accessed easily through conventional channels such as publishers. It includes material documenting government research, non-profit reports, think-tank assessments, reports from observations, investigations, and other primary resource materials.

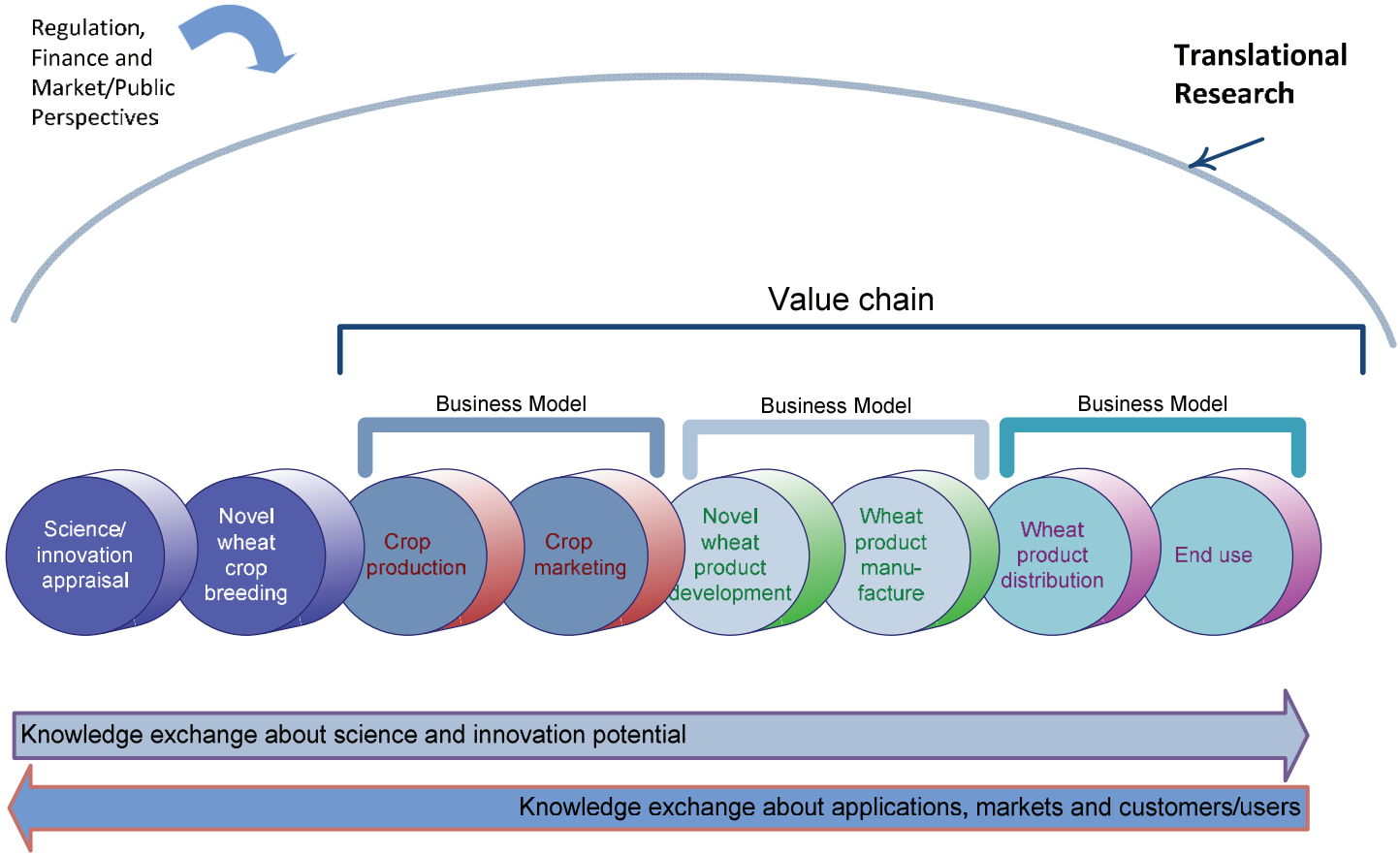
[10] Whilst Figure 2-1 does not directly indicate the actors involved in the wheat value chain, it provides a basis for locating them within the different components based on their activities, and understanding the different points from which they contribute to translational research and knowledge exchange.

value chains[11]. The various intermediaries along each of these wheat value chains will have their own business models, and integration across these business models within the overall value chain will be needed for effective translation of research to contribute to the improvement of products and processes.

Knowledge exchange, as pointed out previously, is multidirectional and flows throughout the broad categories in the wheat value chain. This involves multiple feedback loops which are necessary for effective translational research. The two arrows at the bottom of the diagram illustrate how knowledge about innovation potential and scientific expertise on how to realise that potential tends to flow from left to right along the value chain, while knowledge about applications, markets and consumers' preferences tends to flow from right to left. This latter knowledge is essential for identification of innovation potential at the beginning of the value chain.

However, the use of these two arrows to represent how knowledge is exchanged, although helpful for clarity, gives an overly simplistic impression, given the multidirectional nature of knowledge flows. The arrows are not intended to suggest that knowledge flows in a linear way and necessarily from one end of the spectrum to the other. For example, wheat product manufacture generates different forms of knowledge that may feed directly to crop production.

[11] In this report, the focus of value chain analysis is on wheat in general. It acknowledges that within the broad wheat value chain the main three distinct value chains corresponding to food, feed and biofuels have different characteristics. Specific analysis of each of these three value chains is important in providing detailed information on how they operate. However, in-depth analysis is beyond the scope of this project.



Source: RAND Europe and INNOGEN

Figure 3-1 The conceptual framework for translational research and knowledge exchange in the wheat value chain

3.1.1 The actors of the UK wheat value chain

Working with the categories of knowledge funders, producers, intermediaries and users, we looked at a range of organisations and documented what research they undertake or support in the wheat value chain and who they have collaborated with. These organisations belong to the public sector, private sector, or third sector and they may be regional or international bodies. Appendix G presents the list of the actors within these four categories, which was used to develop matrices[12]. As discussed in Section 2, any actor involved in the value system may take on different roles (knowledge funder, producer, intermediary and user).

Public sector actors include Government Departments, Devolved Administrations, government agencies, non-departmental public bodies, research councils, higher education institutions, and public sector research establishments, statutory levy bodies etc[13].

Private sector actors include private consultancies, private research organisations, trade and business associations, private inspectorate bodies. Others are growers, millers, food and drink producers, feed compounders, biofuel companies, seed companies, sprays (agri-chemicals) companies, equipment manufacturers/suppliers, plant breeders, merchants (intermediaries between growers and food processors), food and drink retailers, co-operatives etc.

Third sector actors such as charities, foundations and not-for-profit organisations may be adopt one of the above roles or be active in multiple roles (knowledge funding, production, intermediation and use). Examples include: NIAB-TAG, Gatsby Charitable Foundation and Organic Research Centre amongst others.

International and regional bodies may also be engaged in multiple roles. Examples of such organisations include: European Commission (funding Framework programmes, New Joint Technology Initiative, ERA-NETS, European Technology Platforms); Food and Agriculture Organization; the International Maize and Wheat Improvement Centre (CIMMYT); and international associations.

3.1.2 The fields of knowledge

For the purpose of applying our methodology, we distinguish different broad fields of research related to upstream and downstream activities. This categorisation is derived from the classification of research fields used in reports and publications relevant to crops (and hence wheat). There was no systematic classification used as a standard and the objective of this categorisation is to be practical and also adequate to capture all fields of research and knowledge generation.

Upstream fields of knowledge, encompassing basic and applied research include: crop science, food science and food safety, organic agriculture, alternative crop use, resource efficiency and climate change, and machinery and equipment engineering[14].

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[12] See Appendix G Table G-1 for more detail on the actors

[13] A detailed description of the responsibilities of these different public organisations with a funding role relevant to the UK wheat sector is provided in the UK Cross-Government food research and innovation strategy (UK Government Office for Science 2010)

[14] See Appendix G, Table G-2 for details on the fields in the upstream activities.

Downstream fields of knowledge covering product and process development include: farm inputs and implements, on-farm production, alternative crop use, resource efficiency and climate change, food science/food safety, food processing, and distribution[15].

Some of the fields are analysed at two different levels, depending on the nature of the research activities that are carried out. For example, within a category 'alternative crop research' it is possible to distinguish translational research activities that primarily involve basic research and this produces outputs that require further research – these are upstream activities. A second type of 'alternative crop research' activities may directly target the commercialisation of products and processes – these are downstream activities. Translational research cuts across both categories of research fields; it occurs around activities within both upstream and downstream categories.

We adopted a matrix approach to record evidence of translational research. The matrix is a useful way of indicating 'who' (which actor) is active in 'which' fields of research. A matrix format provides a useful way of mapping different fields of translational research against different types of actors across the value chain.

3.2 The actors–activities matrix

Having identified the actors engaging in knowledge exchange and translational research and the broad areas of knowledge relevant to the wheat sectors, we developed a matrix in which we recorded evidence of translational research gathered during the study[16]. The matrix format enables us to record the evidence as a combination of actors and fields of research, where the actors are represented along the rows and fields in the columns. The cells indicate evidence of who does what and in which field. This is referred to as the actors–activities matrix.

The matrix data can be used to produce a second matrix which reflects actor/actor interactions in specific fields of research; it indicates who interacts with whom and the interactions are based on the evidence underlying the actors–activities matrix[17].

One important use of the actors–activities matrix is to identify the areas that attract research activity as well as to distinguish active actors from less active ones. In addition, the actors–activity matrix can identify which fields of basic research are being further developed and which ones are receiving little attention.

The source of evidence used to generate the actors–activities matrix is a combination of written material and information obtained from interviews. The written material mainly refers to collaborative projects, and so most of the evidence used to populate this matrix

[15] See Appendix G, Table G-3 for details of the fields in the downstream activities.

[16] This evidence relates specifically to information pertaining to tangible *wheat* research activities that are not only identifiable in terms of their specific contribution to translational research, but can also be traced back to specific sources for further reference.

[17] Further details of the second matrix are presented in Section 3.3.

reflects research collaborations[18]. There is little available evidence about more upstream non-collaborative research in the private sector and we assume that there is much that is not recorded here[19].

3.2.1 Identifying actors' engagement in wheat translational research

The aim is to indicate the activities that relate directly to research being undertaken in the UK wheat value chain. By documenting evidence of tangible research activity from basic science at one end of the spectrum through to end-use, we have moved a step closer to identifying who does what research activity and in what research field. Information on the research activities of actors in the UK wheat value chain was obtained from websites, interviews and grey literature[20]. The primary purpose of gathering information was to provide robust evidence of translational research in the wheat sector. This evidence related specifically to tangible wheat research activities that were identifiable in terms of their specific contribution to translational research. In addition, it was important that the evidence could be traced back to specific sources for further reference. The relevance of research activity to wheat was a primary condition for including information in this study[21]. As such the selection of actors and activities was based on the existence of accessible information on specific wheat-related research activities. **Information that presented a general expression of engagement in translational research in the UK wheat value chain, but with no evidence of specific projects, was not taken into account.**

A summary of the evidence of translational research in the UK wheat value chain is presented in Figure 3-2. Translational research involves knowledge exchange activities and in focusing on translational research this matrix inevitably includes knowledge exchange and networking activities. The matrix excludes translational research activities that are not well documented and publicly accessible[22]. Unfortunately, this may mean that quite a lot of private sector activities are omitted and even some public sector activities for which evidence is not available.

Figure 3-2 summarises the results of the evidence gathered on translational research, colour coded as follows:

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[18] The interest on collaborative research is based on our understanding of translational research in agriculture. It considers collaborative institutional arrangements as an important element. In addition, collaborative research projects provide us with a basis for identifying who interacts with whom.

[19] The recording of evidence depends on the ability to access relevant information. Private sector information on non-collaborative research was not readily available.

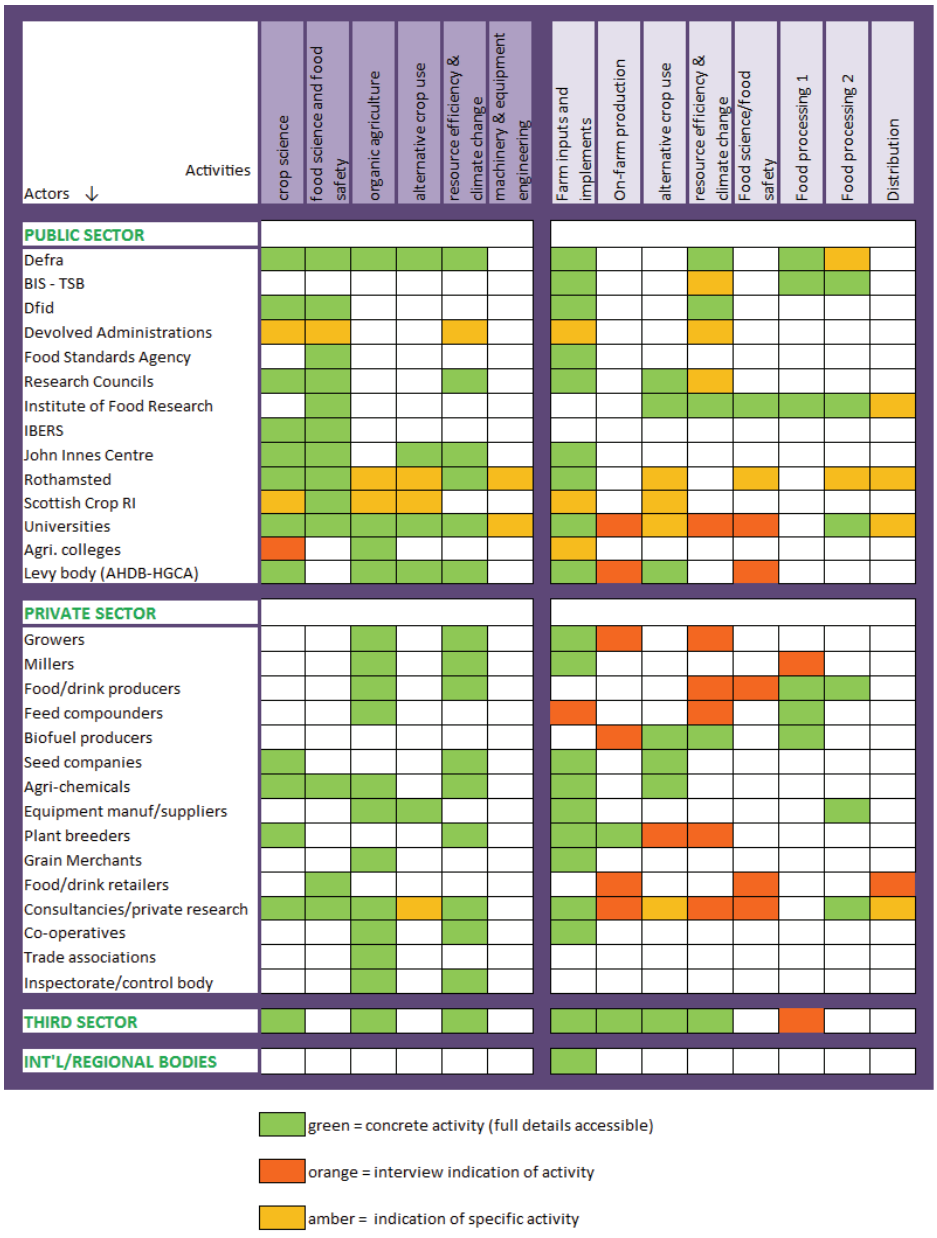
[20] Grey literature in this report is defined in the broad sense and refers to a body of written material that cannot be accessed easily through conventional channels such as publishers. It includes material documenting government research, non-profit reports, think-tank assessments, reports from observations, investigations, and other primary resource materials.

[21] Some research activities that are primarily on other cereal crops such as oat and barley may have some relationship to wheat. Where possible research activity referring to other cereals was carefully screened to assess any relevance to wheat.

[22] This approach takes into account the importance of the ability to trace back the evidence on translational research to specific actors and activities.

- *Green* represents projects whose details were accessed from web portals and grey literature.
- *Orange* represents projects whose details were obtained from interviews.
- *Amber* represents information on actors and activities based primarily on grey literature, which provides details on areas of activity. However, for 'amber' projects it has not been possible to identify specific projects; while the information relates to cereals, it is not possible to identify the extent to which it is relevant to wheat.

Information expressing unspecified interest in knowledge generating activities in the UK wheat sector that was neither attributable to specific projects and/or areas of activity was excluded from Figure 3-2. One challenge of taking such information on board related to the ambiguity between the existence of tangible research activities and aspiration for engagement in translational research.



Source: RAND Europe and INNOGEN

Figure 3-2 Evidence of actors' translational research in the wheat value chain between 2005 and 2010[23]

[23] The evidence that was used to develop the matrix is limited to the period 2005–2010 mainly due to the difficulty of obtaining information that predates this period. For example, most actors' websites do not display projects that were completed over five years ago. There is nevertheless a carefully selected number of Defra funded projects that were completed in the period 2001–2005. The selection of these activities was based on the obvious relevance to translation research in wheat and also due to the relative ease of accessing the information. Defra has a dedicated search portal that systematically records and updates very detailed information on Defra funded projects. This information is also presented in a language that is accessible to the general public.

The empty, white cells reflect two important, but different aspects relating to translational research in the UK wheat sector. On the one hand, *the non existence of activity*; and on the other hand *the non existence of identifiable wheat-related activity* (this is the more frequent explanation).

To give a more detailed explanation, the empty cells can be explained by a number of factors:

- The fragmentation of information across actors and activities (there is no evidence that the gathering of information on translational research and knowledge exchange in the UK wheat sector has previously been undertaken in a systematic way – the difficulties encountered in gathering evidence for this project have been a major challenge in developing the actors–activities matrix)[24].
- A further complexity relating to the fragmentation of information is the disparate understanding of 'translational research' and 'knowledge exchange' by actors across the wheat value chain; these terms are relatively new in the agricultural sector[25]. The search for evidence of translational research entailed very detailed analysis and systematic extraction of the specific elements that relate to translation research from extraneous information. In some cases, it was useful to exclude the term 'translational research' so as to capture material that related to these concepts, but did not explicitly use the term.
- A wide range of knowledge-generating activities in agriculture as a whole contribute directly to the UK wheat sector, although these may neither be specific to wheat or attributable to wheat. Upstream research activities on machinery and equipment provide an example of activities that lead to generic technologies for the agricultural sector with opportunities for further development and adaptation in downstream activities to address specific wheat related challenges.
- Some areas of research draw heavily on complementarities across upstream and downstream activities on the one hand, and across categories of actors on the other hand, for example, across public, private and third sector actors (based on their respective roles as knowledge funders, producers, intermediaries or users). Furthermore, the choice to engage in a specific knowledge generating activity is influenced amongst other things by the wider context (policies, standards, regulations, international trade, skills availability and mobility, and social-cultural aspects that are part of the wider value

[24] For example, it is evident that Devolved Administrations have various efforts aimed at encouraging translational research (invitations to tender provide a good illustrations of such efforts). However, the challenge of collating information that is relevant to the wheat value chain remained considerable. Despite being very cooperative and acknowledging the importance of a translational research evidence base, the Devolved Administrations emphasised that the fragmentation of information was a major difficulty.

[25] The terms have a much longer tradition in the health sector than in agriculture. This was not only apparent in the search for scholarly literature, but also in grey literature, interviews and at the validation workshop.

system in which value chains are embedded.). These factors may influence the pattern of reported engagement across the matrix.

- With regard to downstream knowledge-generating activities and private actors in particular, the public provision of detailed information or tangible evidence about specific activities may not necessarily be desirable, particularly where there is strong potential for commercialisation[26].

3.2.2 Identifying patterns of activities in translational research[27]

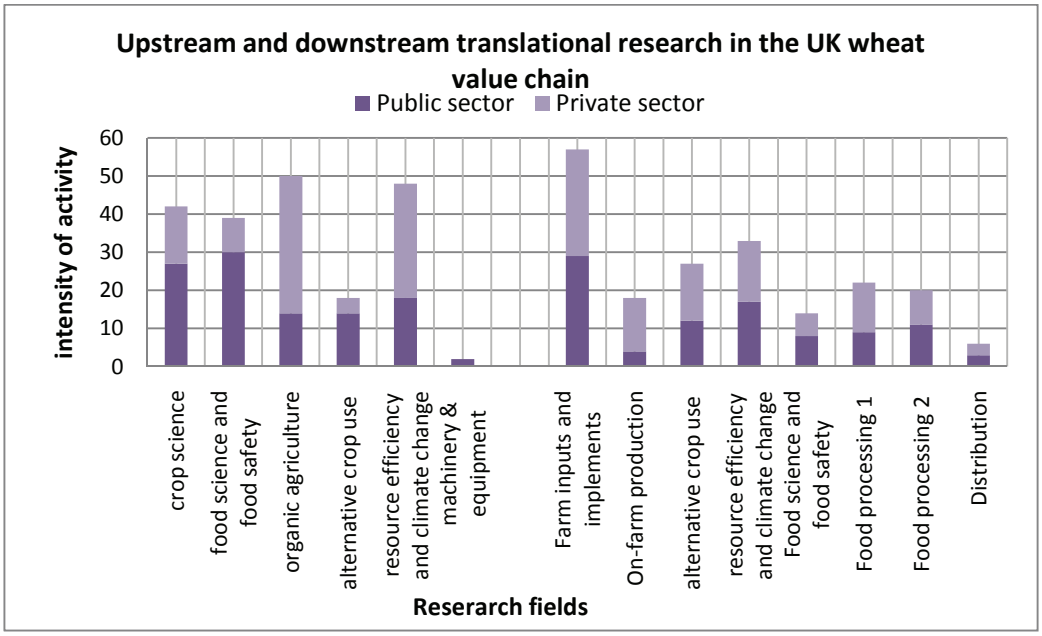
Figure 3-3 presents patterns of knowledge generating activity in the public and private sectors, both upstream and downstream. It is based on evidence of translational research summarised in Figure 3-2. The data have some limitations, as noted above and they do not include financial data. Nevertheless, Figure 3-3 represents the spread and intensity of translational research activity in the UK wheat sector[28]. More comprehensive data could be gathered in future to strengthen the accuracy of this analysis of the nature and extent of translational research in the UK wheat value chain.

With regard to downstream activities, research on farm inputs and implements attracts significant attention from both the public and private sectors. In this analysis these included downstream activities relating to crop protection (pathology/disease control), seeds, genetics, breeding, soil, fertiliser, herbicides, pesticides, machinery & equipment (including precision farming equipment and storage). However, this does not mean that there are no areas where further focus is required. It may be that these upstream and downstream areas where there is considerable activity are the ones that do need further attention. If these areas are strategically important, further knowledge exchange and translational research may be a priority to enhance existing activities. Thus, on the basis of these data it should not be surprising that HGCA prioritises efforts on farm inputs and implements.

[26] Interview responses indicated that it is not unusual to expect collaborative research to occur more frequently in upstream activities, whilst non-collaborative research may be more common in downstream activities. This point is discussed further in chapter 4 and 5.

[27] Any information that presents a general expression of engagement in translational research in the UK wheat value chain, but with no evidence of tangible research activity, is not taken into account in the summary matrix of actors' translational research activities.

[28] The information presented in this figure is based on the colour coding of the summary matrix presenting evidence of actors' translational research activities in the wheat value chain. It presents the information in a way that allows for easier comparisons between the private and public sector on the one hand and fields of research on the other. It does not reflect the financial importance of the different fields.



Source: RAND Europe and INNOGEN

Figure 3-3 Patterns of translational research in the public and private sectors, by research field based on weighted scores of research activities identified in Figure 3-2[29]

An important note about upstream activities is that machinery and equipment engineering are represented only by the public sector. The public sector traditionally funds the development of prototypes from basic research, and these feed into, and are essential for, further development into products and processes for commercialisation. The latter attracts more private sector funding than the development of basic research prototypes. As pointed out previously, the apparently low level of translational research activity on machinery and equipment engineering in the wheat value chain in upstream activities may be an example of knowledge-generating activities that contribute to the UK wheat sector, but are neither specific to wheat nor attributable to wheat. These research activities are relatively generic and target the agricultural sector as a whole. Nevertheless they offer important opportunities for further development and adaptation in downstream activities that address specific wheat-related challenges[30].

3.3 The actor–actor matrix

Based on the wheat-related translational research activities summarised in Figure 3-4 a

[29] Weighted scores are calculated separately for each research field for the public sector on one hand and the private sector on the other – this corresponds to calculating scores for the top half and the bottom half separately. A distinction is also made between the left hand side (upstream activities) and right hand side (downstream activities) of the matrix. In terms of the actual values of the scores, a green cell represents the value 3, and orange one the value 2 and amber one the value 1.

[30] See LINK projects MALNA 1 and MALNA 2 summaries presented in Appendix D on managing late N applications to meet wheat protein market requirements using pre-harvest near infrared sensing. MALNA 1 provided a prototype from basic research that has enable further research in MALNA 2.

matrix to identify actor–actor collaboration was developed to provide an overview of networks and linkages amongst the actors who are engaged in translational research (and related knowledge exchange) in the UK wheat sector (Figure 3-4). This matrix analyses those activities that involve more than one actor, and records the evidence of this multi-actor engagement in translational research (who collaborates with whom)[31]. The overwhelming majority of actors in our evidence base are engaged in collaborative research activities. This summary of actor collaborations in translational research does not make a distinction between upstream and downstream activities, but it has been observed that collaboration is more pervasive in upstream than in downstream activities. However, downstream activities can provide an important secondary step to upstream activities in bringing new products and processes to market and such collaborations may be more private and difficult to access than those in the upstream category[32].

The information on actor–actor collaboration includes both the public and the private sectors. For example, Defra in the capacity of knowledge funder may collaborate with publicly funded research institutes or private plant breeders[33].

3.3.1 Actor collaborations in translational research

Evidence of translation research in this study is based on projects whose details were accessed from web portals and grey literature or obtained from interviews. Information that only provides details on actors' fields of research does not allow for the identification of collaborations in translational research. Therefore, activities represented by the 'amber' cells in Figure 3-2 are not included in the analysis of who collaborates with whom in Figure 3-4[34].

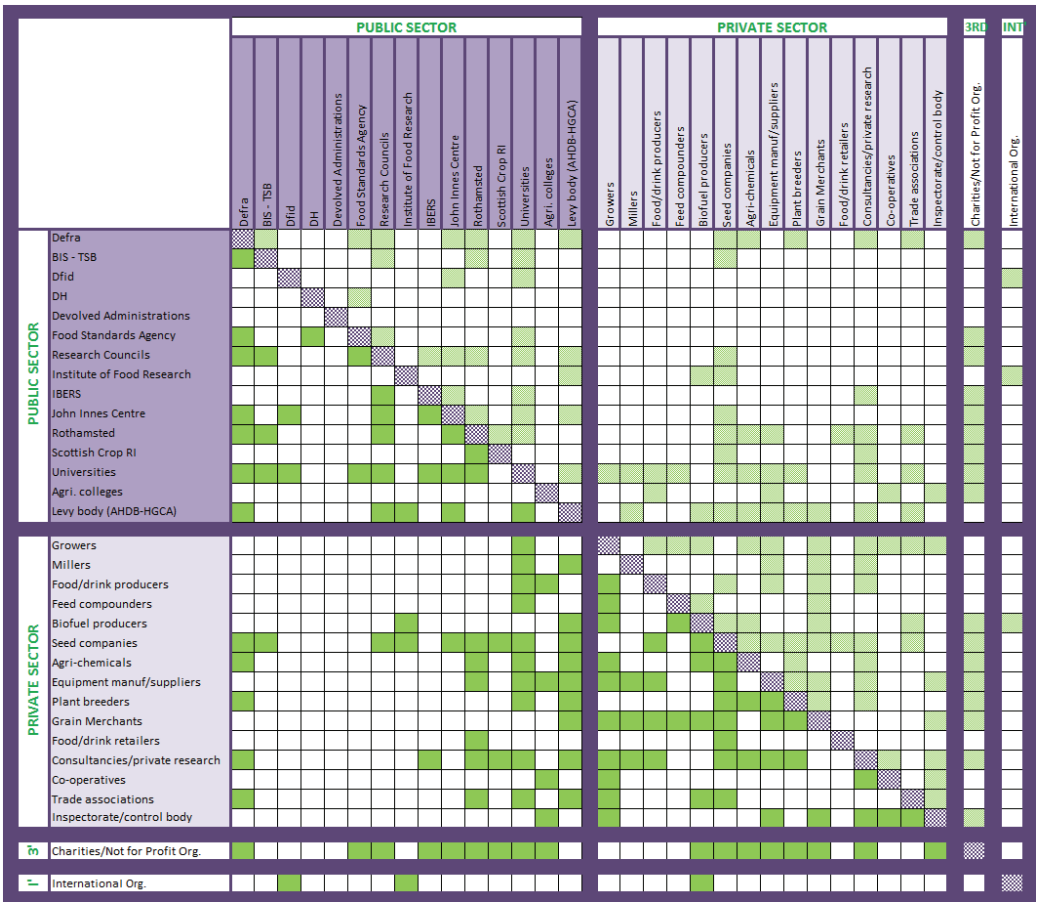
Given that the information used to develop the actors–activities matrix was also used to develop the actor–actor matrix, the arguments for the existence of empty cells in the actor–actor matrix can also be applied to the evidence for collaborations. In addition, most of the evidence for downstream, private sector activities (and also collaborations), came from interviews (orange cells) rather than documentary sources (green cells) – see Figure 3-2 - indicating the difficulty of accessing information of this nature. Nevertheless the matrix provides important information on private sector activities and is a basis from which to explore gaps in translational research and knowledge exchange in future research.

[31] Since the analysis of who collaborates with whom is based on the data that was used to develop the actors-activities matrix the focus is on the actors rather than the fields of research.

[32] There is a limited number of cases where for example, a funder of knowledge is also the sole producer of knowledge. While this is possible particularly in the private sector where non-collaborative research is more common, information on non-collaborative research was not recorded in our evidence base. As discussed previously accessibility to tangible information on non-collaborative research activities is a challenge.

[33] In cases where for example, Defra funds and executive agency such as FERA to undertake research, this is not considered as collaborative research.

[34] The upper right half of Figure 3-4 is shaded in a faded out colour to indicate that this is a mirror image of the lower left.



Source: RAND Europe and INNOGEN

Figure 3-4 Evidence of actors' collaboration in knowledge-generating activities[35]

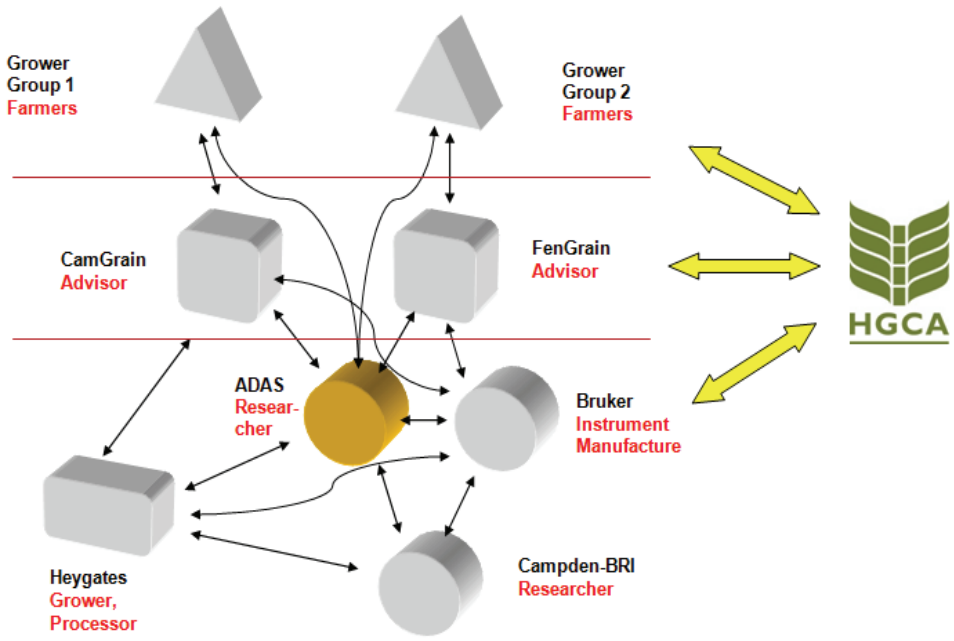
3.3.2 Indentifying interaction nodes in translational research and knowledge exchange

Identifying interaction nodes in translational research and knowledge exchange requires the identification of the actors involved in specific research activities and mapping the activities that are taking place.

Figure 3-5 illustrates actors' interactions in a LINK project that aimed to develop a tool for managing late fertiliser (nitrogen) application to meet wheat protein market requirements[36]. The figure also illustrates the multi-directional nature of knowledge exchange in translational research.

[35] Details of the specific actors and activities underlying the matrices can be found in Appendix G. A snapshot of the level of detail is also provided in Appendix E.

[36] See Appendix D Box D-1 for a description of the project.



Source: HGCA

Figure 3-5 Interaction of actors in developing a technology for predicting the protein content of bread-making wheat

Box 3-1 below describes how actors have been interacting with each other in translational research, an approach that has been instrumental in providing a solution that adds value to the UK wheat sector.

Improving the protein content of bread making wheat

The aim of this project is to develop tools to predict the protein content of bread making wheat to better manage fertiliser application. Near infrared (NIR) forecasting of grain protein content at harvest may be improved by using models taking account of the state of grain development and the likely crop yield. This could improve the farmer's ability to meet high quality wheat targets consistently, and improve the marketability and sustainability of the UK arable sector.

Translational research is being conducted to further the development of the basic research performed in a predecessor project that sought to develop a portable Fourier Transform near infrared device (TN-NIR) to analyse the protein content of immature grain on the farm. This was aimed at assessing optimal nitrogen fertiliser inputs to achieve the quality requirements of bread-making wheat. The project concluded that such NIR assessments could form the basis of an integrated crop monitoring system enabling accurate decision making for the targeted application of late nitrogen for boosting grain protein[37].

The current project brings together key actors from different categories in the value chain (including up to 60 growers who are playing an important role in testing the tool) to provide specific inputs in the translational research activities. Described in terms of the categories of actor involved in translational research, as defined in section 2.5:

- ADAS UK Ltd: consultancy/private research company (knowledge producer and knowledge intermediary) - conducted growing trials, performed measurements/analyses, developed models, engaged in a wide range of knowledge exchange activities such as workshop presentations,

[37] Technical background details of both projects are provided in Appendix E

publications, Open Days and engagements with farmers and co-operatives;

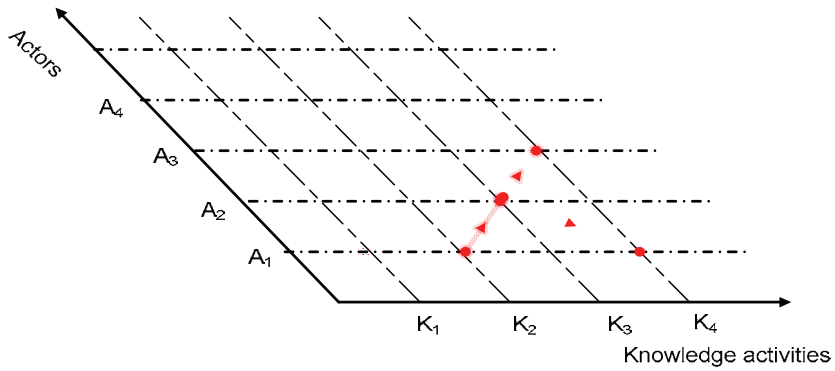
- Campden Technology Ltd: consultancy/private research company (knowledge producer and knowledge intermediary) - performed measurements/analyses, developed models, engaged in a wide range of knowledge exchange activities such as workshop presentations, publications and Open Days;
- Bruker Optics Ltd: equipment manufacturers (knowledge producer and knowledge user) - performed measurements/analyses, developed models, engaged in knowledge exchange activities;
- Heygates Ltd: food processor (grower, miller and baker) - performed measurements/analyses, engaged in knowledge exchange activities;
- Camgrain Stores Ltd: Farmer's cooperative/advisor (knowledge intermediary and knowledge user) - performed measurements/analyses, engaged in knowledge exchange activities with growers;
- Fengrain Ltd: Farmer's cooperative/advisor (knowledge intermediary) - performed measurements/analyses, engaged in knowledge exchange activities with growers;
- Home Grown Cereals Authority: Funder (Statutory levy body) (funder of knowledge generation and knowledge intermediary) - industrial partner/funding body, engaged in wide range of knowledge exchange activities with all other actors;
- Defra: Funder (Government Department) (funder of knowledge generation and knowledge intermediary) - engaged in knowledge exchange activities with the public
- Growers Group 1: Farmers (associated with CamGrain) (knowledge producers and knowledge users) - involved in providing data and testing the technology
- Growers Group 2: Farmers (associated with FenGrain) (knowledge producers and knowledge users) - involved in providing data and testing the technology

Translational research and knowledge exchange have been instrumental in developing a technology that adds value to the UK wheat sector.

Source: RAND Europe (adapted from Defra LINK project descriptions – LK0990 and LK0927)

Box 3-1 Improving the protein content of bread-making wheat

The above illustration of how actors collaborate in translational research can be analysed using a generic tool developed for this project (Figure 3-6).



Source: RAND Europe and INNOGEN

Figure 3-6 Identifying interaction nodes in translational research and knowledge exchange

This shows how the nodes in the grid, representing the intersections between actors and knowledge-related activities, could depict, for example, that actor A1 (plant equipment manufacturer) is developing a specific near-infrared technology (K2) to assess wheat protein on-farm to predict nitrogen fertiliser requirements (K3) involving interactions with A2 (a grower), partly because A2 is involved in field trials of the technology (K3) and also because A2 will use the technology once it is fully developed and approved as a farm input (K4). The technology developer (A1) as well as the grower (A2) are also interacting other

actors, such as A3 (a miller who will also benefit from the devise in certifying the wheat protein quality at the farm gate).

This simple illustration presented in Figure 3-6 was used to understand actor collaboration in the example described in Figure 3-6. The approach could usefully be applied to other knowledge generating activities in the agricultural sectors. By providing focus on the relevant nodes in the complex network of actor/knowledge relationships that are required to deliver value, it could help to provide valuable insights into translational research processes across a wide range of agricultural sectors.

3.3.3 Validation workshop

The two matrices (on actor/activity interactions and on actor/actor interactions in translational research), summarised in Figure 3-2 and Figure 3-4, were presented at the validation workshop held for this project and the following feedback was obtained:

- This could be a powerful tool to identify who does what and who interacts with whom about what field
- There is a risk of missing gaps if no literature or interview reports its absence[38]
- This gives an incomplete picture of what is actually happening and there is a potential risk of never reaching a satisfactory picture due to the difficulty of finding evidence of certain types of knowledge exchange and translational research in wheat
- This is a useful basis for network analysis that can provide further insights into the links between organisations both in terms of density of interaction and of outputs from collaborations

This feedback confirmed the importance of systematically gathering evidence on translational research; there was strong interest from actors' in robust information that would allow them to engage effectively in translational research and knowledge exchange in the wheat value chain. The feedback also acknowledges the challenges of collating such evidence. However, the study is a useful step towards achieving a more comprehensive evidence base and a representative summary of 'who does what and with whom', providing a basis for further analysis of the factors that shape the current configuration of translational research in the UK wheat value chain.

3.3.4 The potential of the matrix

This matrix thus has the potential to be a useful method for tracking wheat-related translational research and knowledge exchange activities over time. Updating of the content of the matrix could provide a much needed overall picture of translational research activities that would contribute to delivering better value more effectively from public and commercial investment in basic knowledge related to wheat production and also for other agricultural sectors.

The matrix spreadsheets could be made available on-line as an information tool. Likewise, the contents of the spreadsheet could be stored on a website that would be accessible

[38] However, as we note above, this observation relates to only one side of this issue. There is also a risk of identifying gaps because non-existence or inaccessibility of information rather than the absence of activities.

through a search tool. Further inputs of data could then be solicited (e.g. in the form of a wiki-matrix) to help to build up a more comprehensive picture of relevant translational research activities by means of user engagement[39].

3.4 Conclusion

The matrices show there is a great deal of translational research activity across different parts of the UK wheat value chain. They confirm the widely held perception of a significant UK crop science activity, including in wheat. They also demonstrate in which areas translational research and knowledge exchange are taking place, and how different actors are collaborating across the wheat value chain.

However, the matrices do not represent a comprehensive guide to all relevant activities. Gathering information about activities related to translational research and knowledge exchange has been a significant challenge and, for the reasons outlined above, the data we have compiled are incomplete. One reason for this is that even relevant people and organisations find it very hard to compile information about activities they are involved with or fund; the complexity of the wheat value chain highlighted in Box 1-1 poses difficulties in identifying and tracking translational research and knowledge exchange in the wheat value chain. Furthermore, not only is the value chain itself fragmented but information about activities in the chain is also fragmented and hard to pull together[40]. If it is difficult for trained researchers to identify information on knowledge generation and exchange, it will be even more difficult for others to do so. This underlying challenge in making information about translational research accessible limits the type and amount of knowledge exchange that can take place around wheat innovation and product development.

[39] See Appendix E for further details.

[40] There is no evidence that the gathering of information on translational research and knowledge exchange in the UK wheat sector has previously been undertaken in a systematic way.

CHAPTER 4

Modes of translational research and knowledge exchange in the UK wheat value chain

Many types of translational research and knowledge exchange, formal and informal, are taking place in the UK wheat value chain, some are publicly funded, some are privately funded, and some are funded through joint private and public funds as explained in the previous chapter.

Based on a semi-structured interview programme and written material we have identified various modes of translational research and knowledge exchange in use in the UK wheat sector. Our definitions of translational research and knowledge exchange (section 2.1) require that these modes offer scope for interactions and dialogue.

The various modes of knowledge exchange identified for this project contribute to the translational research process in different ways and at different points along the value chain to narrow the gap between generation of basic knowledge and the development of product and process applications.

We gathered evidence about these modes of knowledge exchange and translational research during our interview programme. Semi-structured interviews were used to give interviewees ample opportunity to discuss their experiences and interpretations and to contribute data to the project.

Drawing on our categories of actors engaged in knowledge exchange and translational research in a value system (section 2.5), interviewees were categorised as follows[41]:

- knowledge producers (organisations whose core business is research and who may be involved in knowledge exchange or translational research with other partners) of knowledge) – 8 interviewees;
- knowledge intermediaries (organisations whose core business is to make the outcome of research accessible to other parties which may involve the carrying out of research to achieve this goal) – 8 interviewees;

[41] We do not report here on funders of knowledge as they are not themselves engaged as such in knowledge exchange and translational research.

- knowledge users (organisations whose core business is to produce and sell, requiring knowledge of product and process to do so, and possibly engaging in research to improve these products and processes) – 24 interviewees.

The larger number of knowledge users included in the sample reflects the complexity of the wheat value chain. Wheat feeds into many different products and it was important to capture evidence from people involved in the range of product areas relevant to wheat.

Interviewees were drawn from across the wheat value chain and all had significant experience in their areas of expertise. They provided insights into the perceptions, attitudes, experience and expectations of key actors. The small sample size and the method of recruitment of interviewees do not allow direct comparisons across categories. Interview Data have therefore been normalised where necessary for the analysis. Details of the interview process and analysis can be found in Appendix F.

Interview data were analysed in two ways:

The first set of figures refers to the appreciation of the relative importance of different factors associated with translational research and knowledge exchange. The figures present aggregate results from the three interviewee categories (knowledge producers, knowledge intermediaries and knowledge users) for the UK wheat value chain.

The second set of figures is presented in terms of the percentage of interviewees in each of the three categories (knowledge producers, knowledge intermediaries and knowledge users). This provides information on the relative importance of factors cited in the first set of figures to show how the factors associated with translational research and knowledge exchange are appreciated by each category of actor. It also shows how the results compare across the three categories[42].

4.1 Modes of knowledge exchanges

The main modes of knowledge exchange cited in interview responses were:

- conferences,
- events and field days,
- participation in panels and committees responsible for research selection and decision,
- face to face interactions,
- business relationships – with suppliers, with buyers, with consultants and advisors,
- Studentships, training, and
- links with peers from other countries.

[42] The semi-structured nature of the interviews encourage interviewees to identify and express views on as many factors associated with translational research and knowledge exchange as they considered necessary. These factors were then analysed and categorised appropriately.

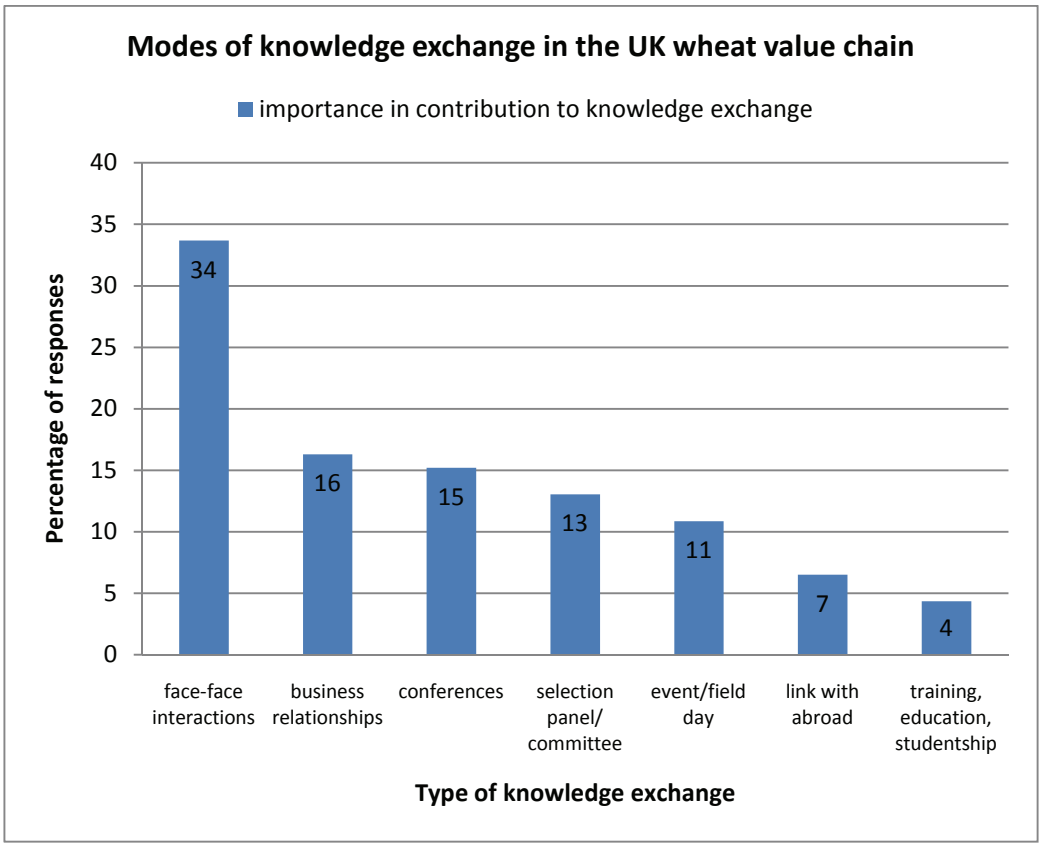


Figure 4-1 Comparison of the importance of different modes of knowledge exchange (based on the percentage of cited responses) in the wheat value chain

Figure 4-1 shows interviewees' appreciation of the relative importance of different modes of knowledge exchange. It represents the overall feedback provided by three categories of actors (knowledge producers, knowledge intermediaries and knowledge users). Face-to-face interaction was by far the preferred mode of knowledge exchange in the UK wheat value chain. Furthermore, although events or field days are treated separately from face-to-face interactions (owing to their specific aims), they are outreach activities tailored to face-to-face communication.

The finding that face-to-face communication is considered the most important factor for knowledge exchange reflects the nature of knowledge that is required for effective translational research. Such knowledge often comprises tacit knowledge; it can only be effective when exchanged directly between actors. Tacit knowledge is thus a critical component of translational research[43], primarily rooted in practical experience and social interaction, and relying heavily on face-to-face interaction (Lundvall, 1996).

[43] Not all knowledge that is used to generate value in the form of new or improved products and processes is codifiable.

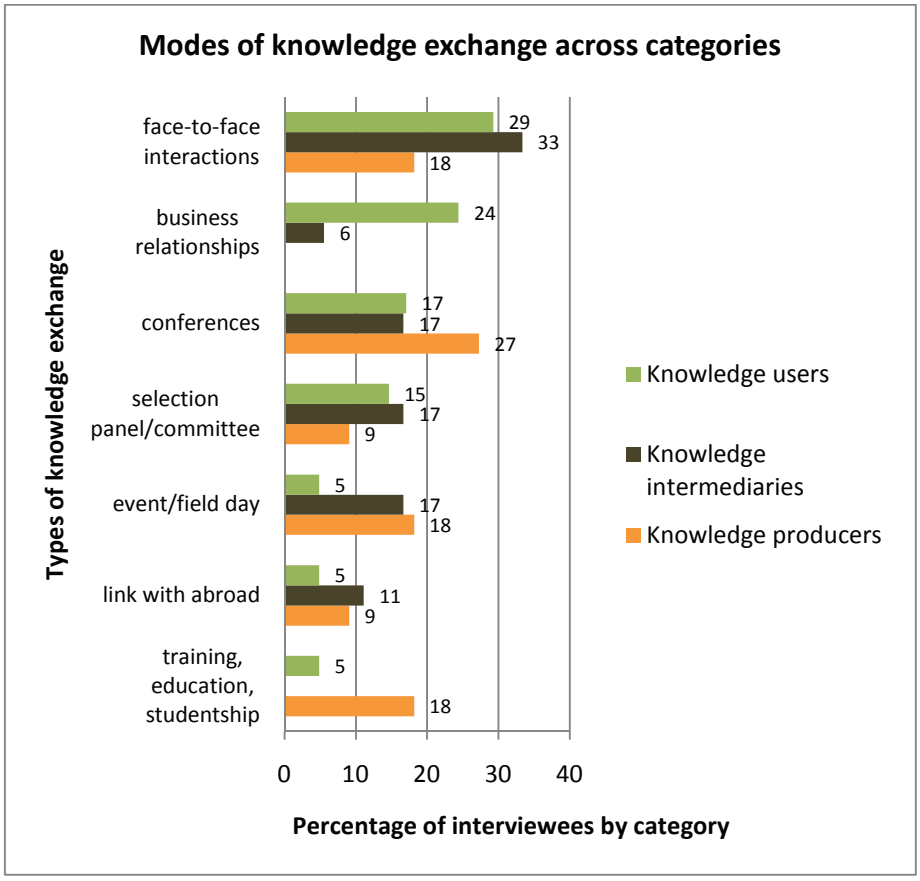


Figure 4-2 Comparison of the importance of different modes of knowledge exchange by type of actor and across actor categories

Figure 4-2 corroborates that face-to-face interaction is the preferred form of knowledge exchange for most interviewees in each of the three categories. This is particularly true for intermediaries and users. Interviewees often followed discussion of the importance of face-to-face communications with observations about the disparate nature of the wheat value chain and the difficulty of getting relevant information and making sense of it. Some interviewees related difficulties to price volatility and the challenges of decision-making in an environment where prices are so unstable.

Balancing the costs and benefits of investments of time and money in knowledge exchange and translational research requires consideration of the particular situation of the investor, and face-to-face communications offer the opportunity for detailed discussion. Published information coming out of the research base, which offers no synthesis of costs and benefits, was mentioned as unhelpful.

Business relationships, also rated as a very important mode of knowledge exchange amongst knowledge users, may also include face-to-face communication. Business relationships are viewed as a standard and essential mode of exchanging knowledge, especially with buyers and suppliers. These interactions were seen as essential to identifying new opportunities and to finding solutions to issues they were facing.

Interestingly, several interviewees indicated that the quantity (and quality) of business relationships decline quickly as they move away from their direct suppliers and buyers.

This is partly compensated for by relying on trade associations to gather information about the organisations further upstream or downstream in the value chain.

Interview data from millers provided a good example of why business relationships were considered so important. In most cases millers work with bakers directly to develop bespoke flour which is suited to the individual customer need. Millers, bakers and food retailers (supermarkets) commented on this type of interaction. One miller said that:

> "Usually discussions occur with bakers (customers) about bespoke flour needs and this leads to improvements on-site in the way the flour is made, so it fits the needs of the baker who might want 'a better crumb structure', etc. This is unscientific input, and the miller's job is to look at the chemical and structural issues and test the new product in their baking labs. This leads to the production of bespoke flours which improve the product and it is a direct knowledge exchange process between the baker and miller."

In contrast, interactions between millers and plant breeders seem to have a more 'research-oriented' motivation in that they are trying to address longer-term issues like higher yield and higher quality of wheat to meet miller specifications. This necessarily involves many more actors across the value chain, from researchers to breeders and the importance of interactions is less immediate. One miller described a few different projects he was involved with, including the LINK project BranScan and research projects that aim to look outside the food industry for new ideas (e.g. duriology was investigated in the Gas Cell LINK project where ideas from plastics and polymer measurement techniques were applied to a project looking at how to measure the content of wheat more efficiently before the milling process begins).

Figure 4-2 also indicates that knowledge producers do not view business relationships as important modes of knowledge exchange. Whilst not surprising, perhaps this does make obvious the difficulties in engaging knowledge producers in conversations with more downstream actors who might provide them with a better understanding of business needs.

Conferences, panels and committees were thought to be important, with interviewees, saying that these modes are valued because they offer a synthesis of relevant information. Conferences were particularly favoured by knowledge producers, but research selection panels and committees were thought of as important by all three groups and particularly by knowledge users and intermediaries.

Figure 4-2 also shows that training, education and studentships were thought of as important by knowledge producers but perhaps unsurprisingly did not seem so significant to knowledge users and intermediaries. Training events that allowed for substantial face-to-face interaction were favoured; one interviewee commented that more informal events that allowed for unstructured interaction were preferable to more formal events; and another said that training in the field was preferable to formal seminars.

Online communications were cited by various interviewees as a source of information but were not explicitly mentioned as a mode of knowledge exchange. It is not clear why this has come across in this manner as emails, blogs, online fora, etc., could be viewed as modes of knowledge exchange, enabling a two-way flow of information and these may already be used by many if not all interviewees. One validation workshop participant expressed his

surprise at this outcome and speculated that the age profile of the interviewees may explain why online communication was not mentioned explicitly. He saw the younger generation as being extremely engaged with online communications as a way to exchange knowledge. This area may deserve more attention as online communication is often cited as a strategy for knowledge sharing and there is evidence that broadband access is uneven across the UK, with poor or sometimes no coverage in rural areas. It may be that these communication modes are excellent for social interaction but are not adequate for the exchange of the complex tacit knowledge and understanding required for effective translational research, where face-to-face interaction is the preferred mode of knowledge exchange.

We now look at the information gathered about translational research modes, as summarised in Figure 4-3 and Figure 4-5.

4.2 Modes of translational research

Translational research includes the outcome of the entire range of knowledge exchange activities across the value chain. This analysis focuses on two modes of translational research:

- Collaborative research
- Non-collaborative research

Collaborative research is funded or carried out by more than one organisation, and these may be engaged in either upstream or downstream projects. Non-collaborative research means research that is funded and carried out, by or for the use of one organisation. Most near-market testing would be non-collaborative given that the risk of losing commercial advantage is a major disincentive for collaborative engagement in near market testing.

Figure 4-3 indicates that of these two modes of translational research. Collaborative research was cited as the more important mode for translational research in comparison to non-collaborative research. The most favoured collaborative research projects were those that drew together academic and industry partners from different parts of the value chain, whose outcomes can benefit all participants.

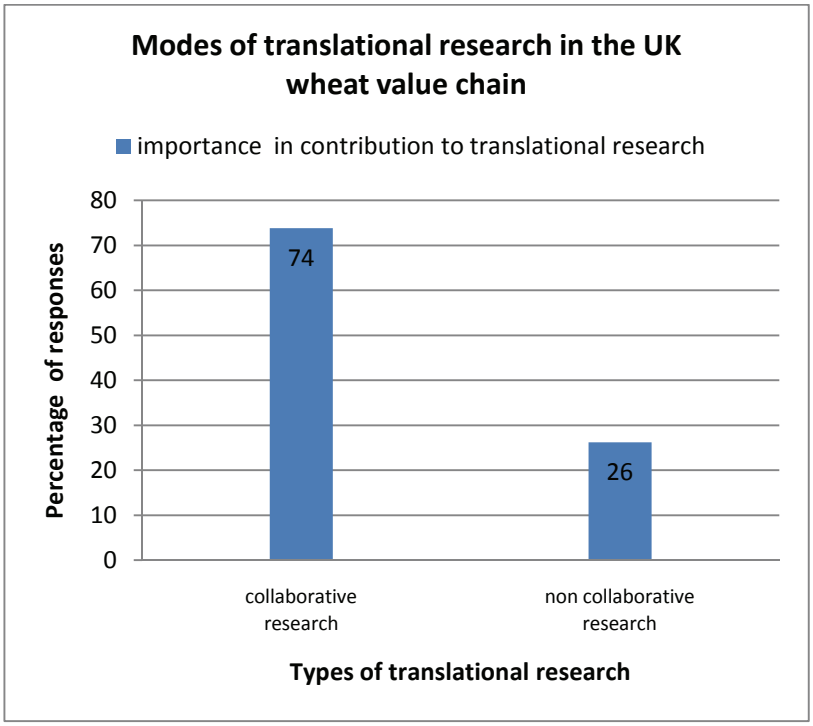


Figure 4-3 Comparison of the importance of collaborative and non-collaborative research in contributing to translational research

As presented in Figure 4-4 non-collaborative research was thought to be important for translational research by knowledge users only. This relates to confidentially commissioned translational research mainly intended to reduce the risk of losing commercial advantage.

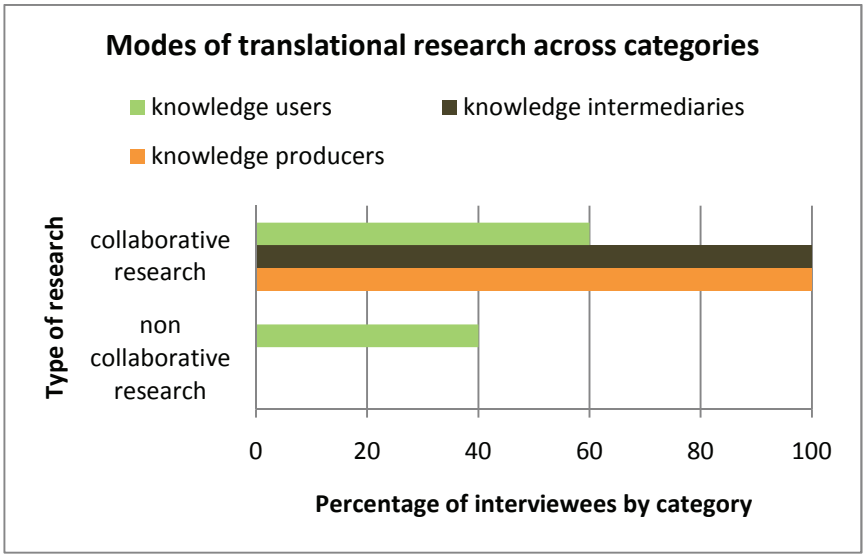


Figure 4-4 Comparison of the importance of collaborative and non-collaborative research (in contributing to translational research) by type of actor and across actor categories

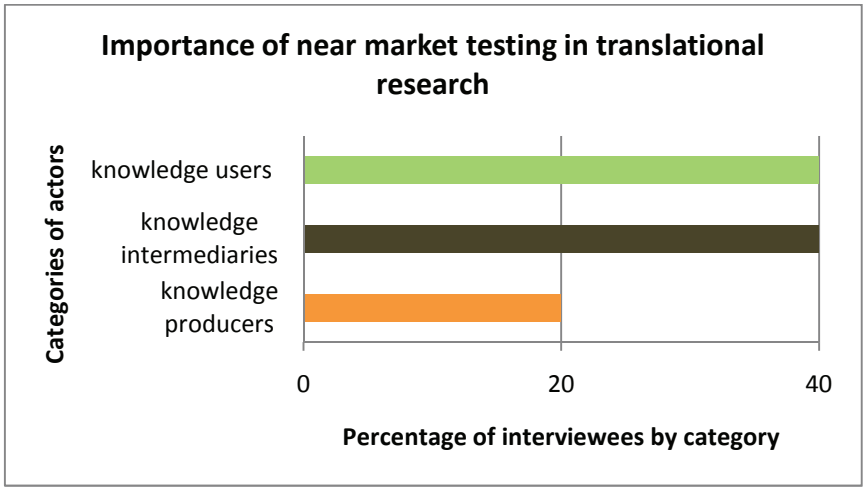


Figure 4-5 Comparison of the percentage of interviewees across actor categories identifying near-market testing as an important factor for translational research

Figure 4-5 shows the percentage of interviewees broken down by actor type who considered near-market testing to be an important component of translational research. Equal proportions of knowledge users and knowledge intermediaries considered near market testing as important for translational research but the percentage of knowledge producers with this view is much lower. This is unsurprising given that near market testing is generally a downstream activity. It is also interesting to note that, although the proportion of knowledge producers is lower than the other categories of actor, knowledge producers from both public and private sectors did consider this to be moderately important. Although we need to view this finding with some caution it does indicate that knowledge producers are operating across basic and applied research domains.

The interviews also gave an indication of key programmes and organisations for knowledge exchange and translational research in the UK wheat value chain. This included in particular the LINK projects, HGCA, Campden-BRI and trade associations. The TSB scheme, the Sustainable Agriculture and Food Innovation Platform (SAF IP), Knowledge Transfer Networks and Research Technology Clubs were mentioned to a lesser extent. Several interviewees talked about ADAS, the important role it used to play while it was publicly funded and the reduced relevance of its current activities now that it has been privatised.

The translational research programme most cited was the LINK programme which has been running for several years, and is now operating on a limited mode with some funding now being directed instead towards the SAF IP. Some interviewees viewed this more recent initiative positively but several expressed their disappointment and concern at the change. For instance, one knowledge intermediary said that TSB and SAF IP may be too industry-focused because it will not fund more upstream activities but it also might not sufficiently fund near-market activity. Another knowledge producer worried that TSB was giving too much funding and importance to private sector funders. Another knowledge user said the appeal of the LINK scheme was that it produced 'bankable' knowledge. It did not always achieve the stated aim of the research project but engagement in LINK research over the years had yielded many benefits. The worry would be if TSB schemes lost this flexibility and impact. SAF IP directly targets the improvement of knowledge exchange and

translational research and has so far funded one initiative, the Crop Protection competition; its flexibility is yet to be appreciated as the initiative matures.

Fewer interviewees mentioned the SAF IP than LINK, not surprisingly because it is more recent. The role of HGCA as knowledge exchange catalyser and translational research actor was mentioned by many, especially from the knowledge intermediaries and users. Some knowledge producers described how they benefited from HGCA support to ensure that the outcome of their research is disseminated and reached end users.

Campden-BRI was referred to by several knowledge users, especially those active in the more downstream part of the UK value chain (food and drink manufacturing).

Given the small size of the interview programme compared to the number of organisation active in the UK value chain, we view citation of any specific knowledge transfer networks (KTN), research and technology centres (RTCs) or trade associations as reflective of the interviewees' identity, more than the level of activity or relevance of the KTN, RTCs or trade associations mentioned.

The workshop confirmed the importance of face-to-face interactions and of the diversity of knowledge exchange and translational research modes and schemes in the wheat value chain as well as the important role played by various organisations. For example, farm assurance schemes such as those run by the British Society of Animal Science and the proposed BBSRC advanced training partnerships were mentioned as important avenues for knowledge exchange and translational research.

4.3 Motivations to engage in translational research and knowledge exchange

The evidence we gathered reveals that organisations often engage in knowledge exchange and translational research for more than one reason, and that the reasons tend to differ depending on the organisation.

Interview Information suggests the following motivations:

- Adding value
- Supporting the core business
- Monitoring knowledge developments
- Learning from others

Figure 4-6 and Figure 4-7 present the evidence relating to these motivations from the interview programme. The results are based on analysis of transcripts, drawing on interviewee accounts of reasons for spending effort and resource on knowledge exchange and translational research activities.

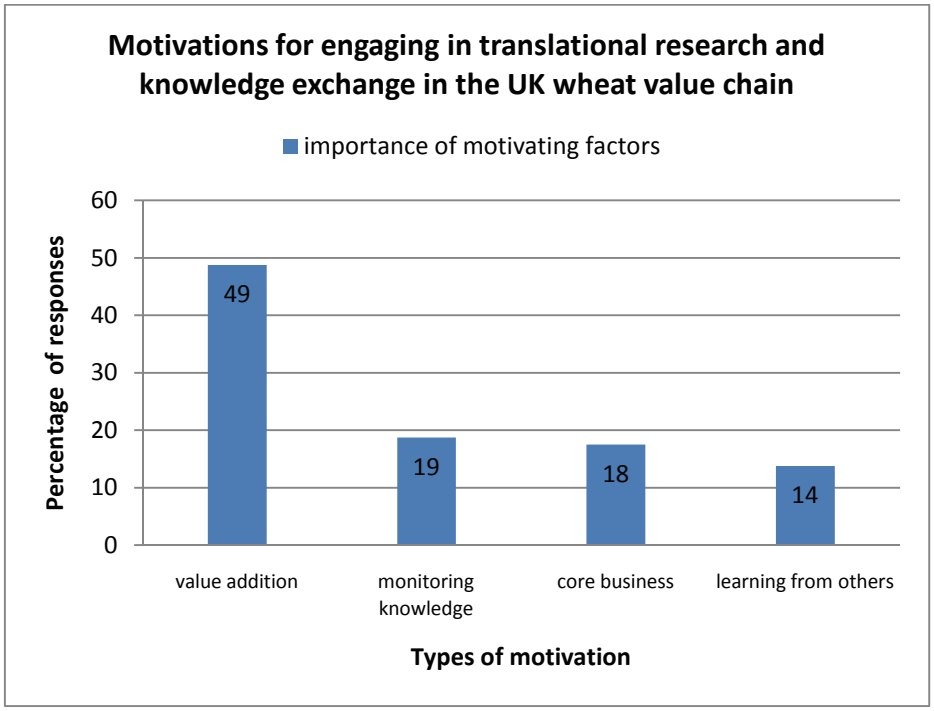


Figure 4-6 Comparison of the importance of different motivations for engaging in translational research and knowledge exchange (based on the percentage of cited responses)

The Figure 4-6 indicates that, overall, the main motivation to engage in knowledge exchange and translational research is value addition. This is particularly true for knowledge users and intermediaries as shown in Figure 4-7. Another important motivation is to monitor the stock of knowledge, although this was more important for knowledge intermediaries and knowledge producers than knowledge users. For knowledge producers monitoring knowledge is more important than value addition. This is an expected outcome since new ideas, and hence the importance of monitoring knowledge, play a key role in knowledge production. This reflects the importance of economic contributions made by knowledge exchange and translational research.

It is also important to note that interviewees spoke about maintaining or increasing margins and profits using slightly different terms and with different concerns from the main foci of this project. Both in interviews and in the workshop people spoke about the persistent volatility in price and the complexity of the value chain, making it difficult to assess what benefit will result from knowledge exchange and translational research activities. In the short run, price volatility and the unpredictability of prices increases the risk of engaging in translational research and may undermine the benefits of translational research. However, from a longer term perspective, translational research may provide solutions for coping with price volatility.

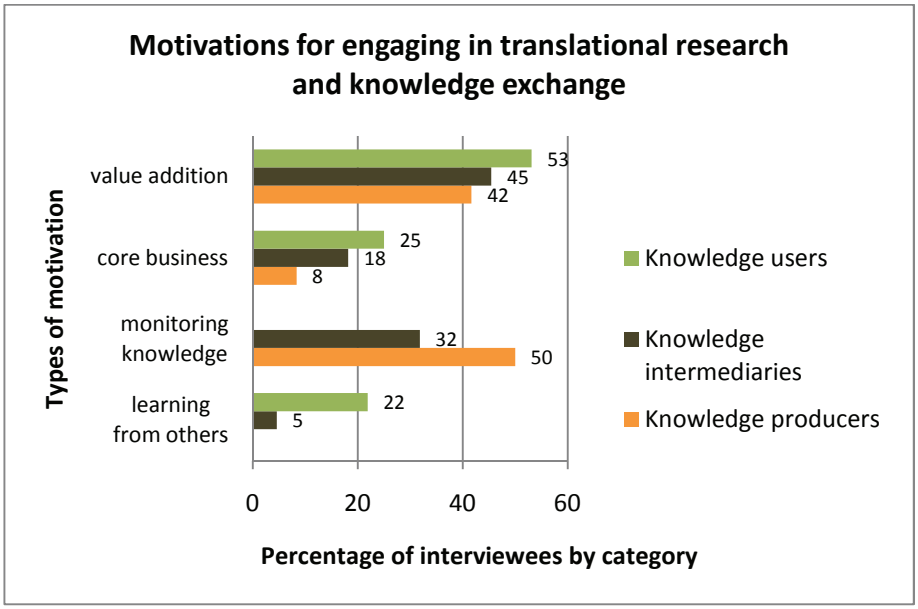


Figure 4-7 Comparison of motivations for engaging in translational research and knowledge exchange by type of actor and across actor categories

Figure 4-7 shows that knowledge producers do not view learning from others as a significant motivation to engage in knowledge exchange and translational research but do see monitoring knowledge as important. This finding should be treated with some caution but it may reflect the orientation of many knowledge producers towards a desire to work on their own research problems, often quite tightly defined. Thus, whilst monitoring knowledge is seen as important, the degree to which one can learn from others is limited. This is in contrast to the high value placed on face to face interaction in Section 4.1 above and would require further research to explore the basis of these motivations.

In many cases the need to solve a specific problem motivates actors to engage in knowledge exchange and translational research. This was mentioned by many interviewees as a key driver, structuring relationships in this area. The statutory levy body, trade associations and industry bodies were identified as key organisations providing the conditions for problem-solving dialogue to take place in the industry. The following organisations were frequently mentioned by knowledge users during interviews: HGCA, Campden-BRI, National Association of British and Irish Millers, National Farmer's Union, and British Society of Plant Breeders.

Knowledge users often revert to their trade associations and industry bodies when they identify a problem which is too difficult or generic and for which a collaborative approach to a solution would be most effective. However if the solution is likely to generate a competitive advantage, knowledge users prefer a confidential or exclusive approach and they will either carry out research in-house or sub-contract it to knowledge intermediaries or knowledge producers with the relevant expertise and infrastructure.

Publicly funded programmes encouraging such dialogue and/or providing funds for stimulating translational research and knowledge exchange also play an important role. Because of regulatory constraints on which types of knowledge activity can be publicly funded, the motivations for knowledge users to participate in these activities are not

directly commercial, but relate more to monitoring the evolution of knowledge and to learn from others. In other cases the knowledge exchange and the translational research activities take place between actors facing a problem and actors with the capacity and capability to find a solution to this problem. This is typically the role played by knowledge intermediaries. Among the knowledge users, this type of dialogue also often takes place as part of business relationships.

4.4 Validation workshop

Discussion in the validation workshop focused on the importance of profitability as a motivation for engaging in translational research and knowledge exchange but some participants made the point that price reduction rather than premium pricing for additional quality is the driver for many activities undertaken by farmers and smaller businesses. Participants emphasised that translational research and knowledge exchange were important in addressing mounting pressure from end users for cheap products. However, they confirmed the complexities involved in making decisions on translational research; some considered the availability of information on translational research and knowledge exchange to be an issue in determining expected returns to investment.

4.5 Conclusions

Responses from interviewees point to the importance of face-to-face and one-to-one communications. This appears to be the most important form of knowledge exchange for knowledge users and intermediaries and reflects the importance of tacit knowledge in translational research. This finding may have important implications for policy.

In translational research, the difficulty that interviewees and workshop participants have in assessing the economic value of activities may be significant. These findings are an indicator of the uncertainties and difficulties in pursuing knowledge exchange and translational research activities in a very volatile market environment. It may also point to the need for more and better assistance in interpreting data and information about future trends and likely impacts of investments. Face-to-face interviews offer synthesised and accessible information and their popularity reflects this desire for assistance in assessing available options.

CHAPTER 5 Barriers and enablers of translational research and knowledge exchange in the UK wheat value chain

This chapter explores the barriers to and enablers of knowledge exchange and translational research. Most of the evidence presented here is derived from our interview programme, supplemented by reference to written material and by the validation gained from the workshop.

The results of the interview analysis on barriers and enablers are depicted in two ways. As in the previous chapter, one set of figures refers to the appreciation of the relative importance of different factors enabling or hindering translational research and knowledge exchange. The results present the aggregate results from the three interviewee categories (knowledge producers, knowledge intermediaries and knowledge users) for the UK wheat value chain.

The second set of figures considers the percentage of interviewees in each of the three categories (knowledge producers, knowledge intermediaries and knowledge users) analysed separately. This provides disaggregated information by category on the relative importance of the factors cited in the first set of figures and shows how the factors enabling or hindering translational research and knowledge exchange are appreciated by each category of actors. It also shows how the results compare across the three different categories[44].

5.1 Barriers to knowledge exchange and translational research

We identified eight broad categories of barrier to knowledge exchange and translational research:

- *Academic career incentives*. Incentives to prioritise excellent academic output over any other outputs lead to basic research that may not be in line with end-user needs. This theme refers explicitly to the academic promotion system that rewards publications in internationally recognised academic journals interested in fundamental research more than in applied research.

[44] The semi-structured nature of the interviews encouraged interviewees to identify and express views on as many factors associated with translational research and knowledge exchange as they considered necessary. These factors we then analysed and categorised appropriately.

- *The lack of capacities and capabilities to support translational research*. There is a limited number of individuals with the skills required for translational research and a reduced number of locations where translational research takes place. These limitations were often explained with reference to the period some time ago when the government subsidised a national extension service, with farm advisors patrolling farms in the UK and with demonstration farms and applied research centres in various locations in the UK testing varieties and showing the outcomes of trials in regional conditions.
- *Differences in time-scale*. This refers to difference in timings faced by different communities involved in the UK wheat value chain. In particular, discrepancies between times-scales for funding research and the length of time required for benefits to accrue; the former was viewed as short in view of crop seasonality - testing over several seasons is often important in agriculture. Differences in time-scale between the industry and academics as well as between pre- and post- farm gate were also mentioned.
- *Collaboration and competition*. Concerns about losing commercial advantage through collaboration with other industry partners that are rivals at the market stage were important. This means that industry partners were more cautious about engaging fully in case this gave their partners and rivals a commercial advantage.
- *Cultural and social barriers*. There was a perceived misalignment of interests or (deep) misunderstanding that exists along the value chain. Cultural and social differences between knowledge producers and knowledge users were mentioned as acting as a barrier.
- *Policy and regulatory barriers.* Legislation preventing certain types of products or processes from being used for reasons of environmental, health or other reasons were seen as presenting barriers to translational research. Examples included regulations related to genetically modified organisms (GMOs) in crop breeding; stricter nitrate regulations; restriction in licensing and application of pesticides; grain assurance; and DEFRA biodiversity targets.[45] However, interviewees also spoke about regulation as an enabler of translational research and we also report on these findings. This theme also refers to the confusion faced by actors in the wheat value chain as to which policy objectives are given priority and how these priorities change over time, potentially making investment in translational research less relevant and profitable by the time the outcome is ready for commercialisation.
- *Time and costs*. This refers to the time and costs required to engage in translational research and knowledge exchange and also to the time it takes for a research programme to generate user-relevant outcomes. Poor or limited returns expected from translational research and knowledge exchange are a barrier to engaging in these activities and better understanding of the likely returns would make it easier

[45] See presentation of Richard Summers to APPG –STA Feb 2010; at http://www.appg-agscience.org.uk/linkedfiles/richard%20summers%20presentation.pdf.

for organisations to engage. Related to this is the perception that there is a lack of willingness to pay for innovative wheat products by buyers and that even if translational research generates something positive, buyers would not be ready to pay a premium for the improvement.

- *Public funding structure*. This refers to the eligibility criteria for public funding of research. Some criteria ban private organisations from leading projects; others give priority to scientific excellence rather than translational opportunities.

Figure 5-1 and Figure 5-2 summarise the findings from the interview programme on barriers to knowledge exchange and translational research. There was an open question on this issue in the interview protocol and leading to a wide range of issues raised. Interviewees were not limited to singling out one barrier and most of them reported more than one barrier. Responses are clustered around the eight themes identified above.

Figure 5-1 indicates that policy and regulation are seen as important barriers to translation, as cited by almost a fifth of the interviewees. The proportion of interviewees is fairly evenly spread across the three categories, with a slightly higher proportion among knowledge users than knowledge intermediaries and producers (see Figure 5-2). The most cited example was genetically modified (GM) crops where the European policy was viewed as a wall preventing translation of knowledge generated into applications for the UK wheat value chain.

Sometimes regulation is difficult to deal with but still provokes engagement in translational research. For example, one knowledge user spoke about difficulties in managing and dealing with current acrylamide regulations but also pointed to LINK projects that had been undertaken with the purpose of looking for alternatives.

As the figure shows, cultural and social barriers were also highly cited within the industry as well as between industry and academics. This was particularly the case for knowledge users; Figure 5-2 indicates that one quarter of interviewees thought that cultural and social rigidities presented the most important barrier to translational research and knowledge exchange. The following comments give an insight into these problems.

A number of interviewees and workshop participants considered farmers to be conservative, leading to difficulties in engaging them in knowledge exchange and translational research.

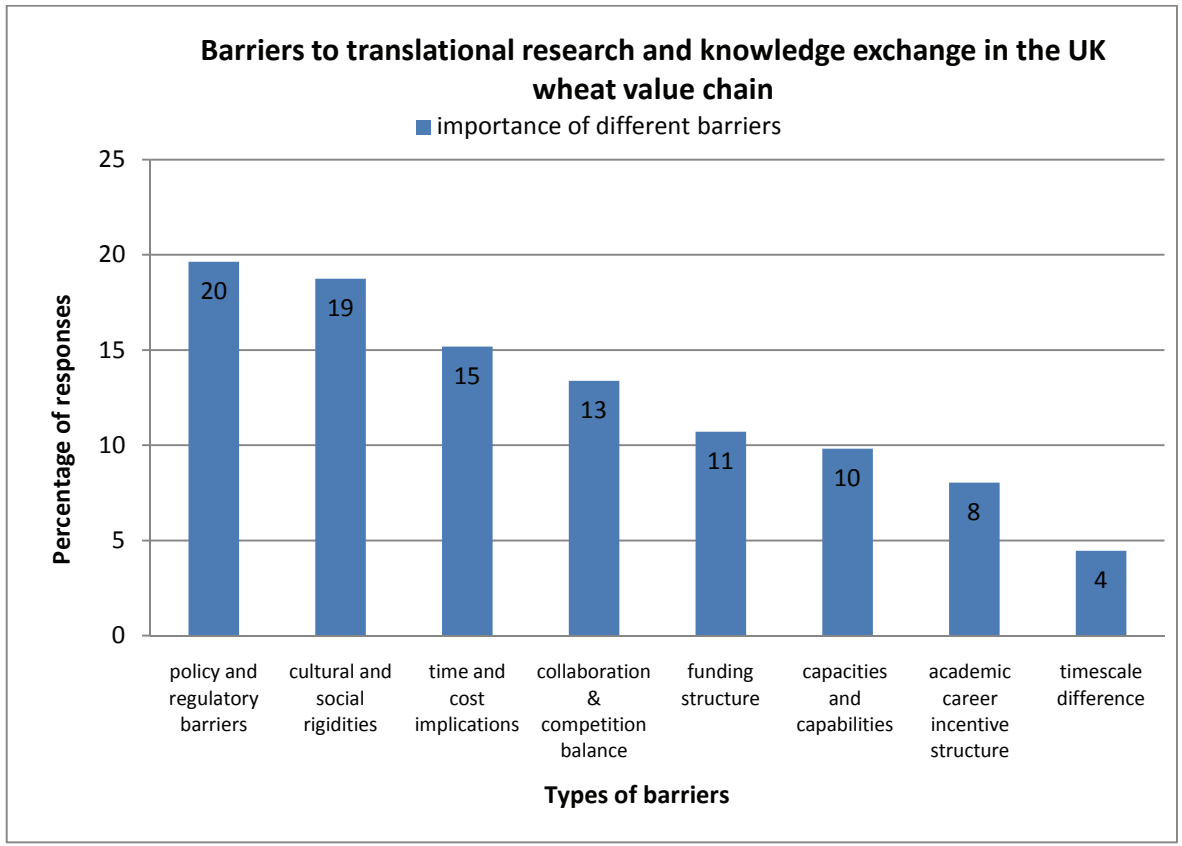


Figure 5-1 Comparison of the importance of barriers (based on the percentage of cited responses) in deterring translational research and knowledge exchange in the wheat value chain

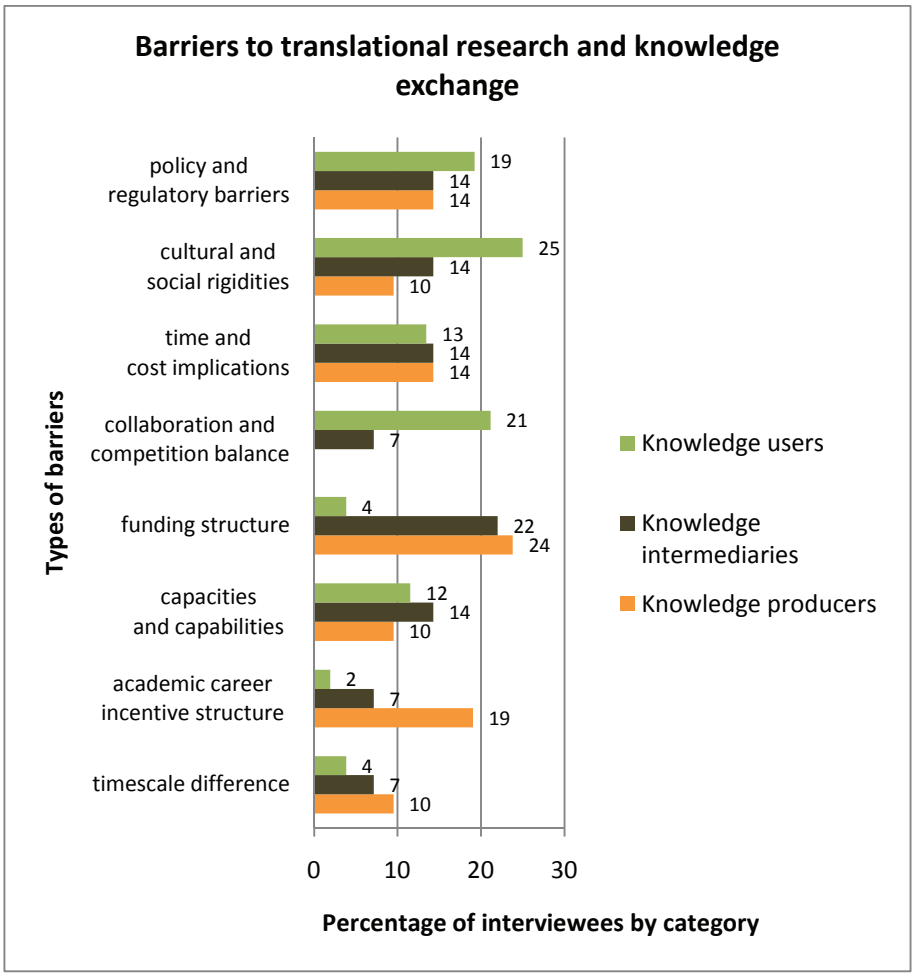


Figure 5-2 Comparison of the importance of barriers to translational research and knowledge exchange by type of actor and across actor categories

Another interviewee thought that agriculture was not considered 'prestigious' and GM had a negative image which deterred investment in knowledge exchange and translational research. A number of interviewees saw overcoming public resistance to GM as key to generating investment in translational research. A knowledge funder thought that state subsidies had slowed the extent to which knowledge exchange and translational research had taken place in wheat saying:

> "Innovation and technology happens most in those areas which have not, historically, been heavily subsidised by the state' and citing the less subsidised poultry and pig sectors as highly innovative."

Another set of issues in this theme of social and cultural barriers related to communication difficulties and fragmentation across the value chain, for example communicating across the range of actors involved in serving different markets. Interviewees and workshop participants pointed to the different sub-sectors in wheat: animal feed, food, and biofuels. The diverse needs and practices of those engaged in each sub-sector fragments the demand

for knowledge exchange and translational research. However, this was largely seen as a cultural issue that could be overcome by more attention to communication barriers.

A number of interviewees pointed to important benefits that could be derived from communicating across these sub-sector barriers. For example innovation in bio-fuels has had important implications for those involved in the animal feed sub-sector and increased communication might lead to more translational research benefiting both sub-sectors. One workshop participant felt that the new impetus in biofuels made possible new connections across the wheat value chain and welcomed initiatives that would allow this to happen.

Some interviewees spoke of a concern that the UK was losing the capacity to undertake knowledge exchange and translational research activities. One person thought that industry was increasingly unable to articulate its needs and that this was a barrier to translational research. A knowledge user was one of a number of interviewees who thought that the demise of state-funded extension services had been a blow to knowledge exchange and translational research. However, as mentioned previously, other interviewees and workshop participants viewed the lack of state subsidised services as a motivation for engagement with translational research. It may be that learning from experience across different sectors in agriculture could help actors to think through alternatives to state subsidies.

> "A desire to involve many partners can be a barrier to efficiently getting research done, transferring knowledge between too many people. It is also difficult when competitors are in the same room – it can make you reluctant to share knowledge."

Some interviewees expressed frustration with government funding structures, a concern being that there was insufficient funding for applied research. One knowledge producer was worried that small businesses find it very difficult to access research funding (as opposed to business development grants). Although BBSRC offers some relevant funding, competition is fierce and more funding is needed.

Some interviewees, mainly knowledge producers, thought funding structures and mechanisms favoured industry too much. Others, however, were frustrated that funding mechanisms do not allow for sufficient private sector leadership. A number of private sector interviewees felt that current funding mechanisms lacked flexibility; although TSB schemes do allow leadership they were thought to be overly prescriptive in the type of partners that had to be involved.

Some interviewees may have been unaware of how different funding mechanisms operate and this could indicate a need for more information about the different types of mechanisms available.

In relation to academic incentives, several knowledge users talked of the lack of focus of academic research on 'real problems' and an outdated view of the private sector among academic researchers as a cultural barrier. For example one interviewee said:

> "The view of scientists is that if you're in a company you're not a real scientist. BBSRC has this view to a certain extent, too, and it's important to try and show how industry can work with research and be a part of the research process in knowledge exchange."

Interviewees (particularly knowledge producers) and workshop participants did not think that the universities' research excellence framework (REF) and the introduction of non-academic impact criteria would necessarily make a difference, as the root cause may be more to do with deeper cultural factors.

Some interviewees spoke about the time-scale difference between academic and industry research, as well as between crop-related research (pre-farm gate) and food processing (post-farm gate). For example, the following comments were made:

> "Industry works on a timescale of weeks/months. Research works on a timescale of 24 months or longer, this is a real barrier to knowledge exchange and efficient uptake of research."

> "Neither the wheat crop side nor the food/baking side is more or less dynamic, but it's a question of time scales. The baking/food side is introducing new products/processes on a scale of weeks or months, whereas new crops can take at least 8 years from first cross to regulatory approval and/or inclusion on the Recommended List."

This issue of course is not confined to wheat or even to agriculture. To some degree the same issues related to a wide range of industries including health, clothing and furniture. Value chain analysis indicates that the issue of different timescales of change in different parts of the chain is an important feature and characteristic of particular sectors (Kaplinsky, 2006). Knowledge exchange and translational research initiatives need to take into account the realities of each value chain and to find ways to facilitate communication across parts of the chain operating on different innovation timescales. Cross sector comparisons may be useful in this regard.

5.2 Validation workshop

The workshop discussion confirmed many of the barriers identified during the interview programme.

The lack of profitability and low margins for many organisations in the UK wheat value chain were mentioned several times as factors constraining knowledge exchange and translational research. This was contrasted with the health sector. The difference between agriculture and health sectors is compounded by a stark variation in the widely held expectations about the impact of innovation. In health, it is expected that innovation will lead to increased margins for health products and greater returns. In agriculture, innovation is mostly expected to lower costs and reduce expenditure.

Participants expressed the view that the fluctuations in the price of wheat have introduced instability and insecurity. Tensions between end users and suppliers of wheat, with farmers wanting more for their crop whilst food, feed and bio fuel manufacturers are looking for low-cost raw materials underlie this perception.

The complexity of the wheat value chain, which is long and feeds into many products, was thought by many to hamper knowledge exchange and translational research. Workshop participants highlighted issues related time-scales, also raised by interviewees: (i) difference in timing of research across different segments of the wheat value chain; (ii) the time-lag

discrepancies between funding research period and the time-scale required to attain goals (in particular the funding cycles mostly reflect the 4–5-year electoral process, whereas it might take 10 years to deliver against complex challenges, creating a lack of long-term commitment).

Academic career incentives were confirmed as barriers. Doubts were expressed that the new REF assessment will make a significant impact in the short term. The underlying issues were seen as associated with deeper cultural factors.

The issue of lack of skills and capability as barriers was also discussed, including the view that the skills needed by farmers and others in the industry to use new technologies and products are lacking and that these skills are expensive to build up and hence are ignored.. Related to this is the absence of knowledge transfer skills. Some participants would welcome formal training opportunities to develop these skills.

Lastly, participants expressed concern that wheat has not been a government priority for a long period. However, they cited the Wheat Genetic Improvement Network (WGIN) as an important recent government effort.

5.3 Enablers of translational research and knowledge exchange

This section presents the evidence related to factors enabling knowledge exchange and translational research, clustered around the following themes:

- *Targeting end-use*. A focus on shared objectives and problem solving
- *Focussing on pre-competitive topics.* Competition and secrecy can be a barrier and defining a pre-competitive approach can enhance collaboration
- *Involving key actors*. A common understanding of knowledge exchange and translational research activities needs to be undertaken across all actors
- *Multi-disciplinarity.* Appropriate forms of multi- and inter-disciplinarity
- *Fora to facilitate knowledge exchange and translational research*. Fora which offer opportunities for knowledge exchange and translational research and synthesis of information and knowledge
- *Policy, legislation and regulation*. Policy, legislation and regulation that enable knowledge exchange and translational research and innovation
- *Availability of funding for translational research*. Increased levels of funding for knowledge exchange and translational research activities

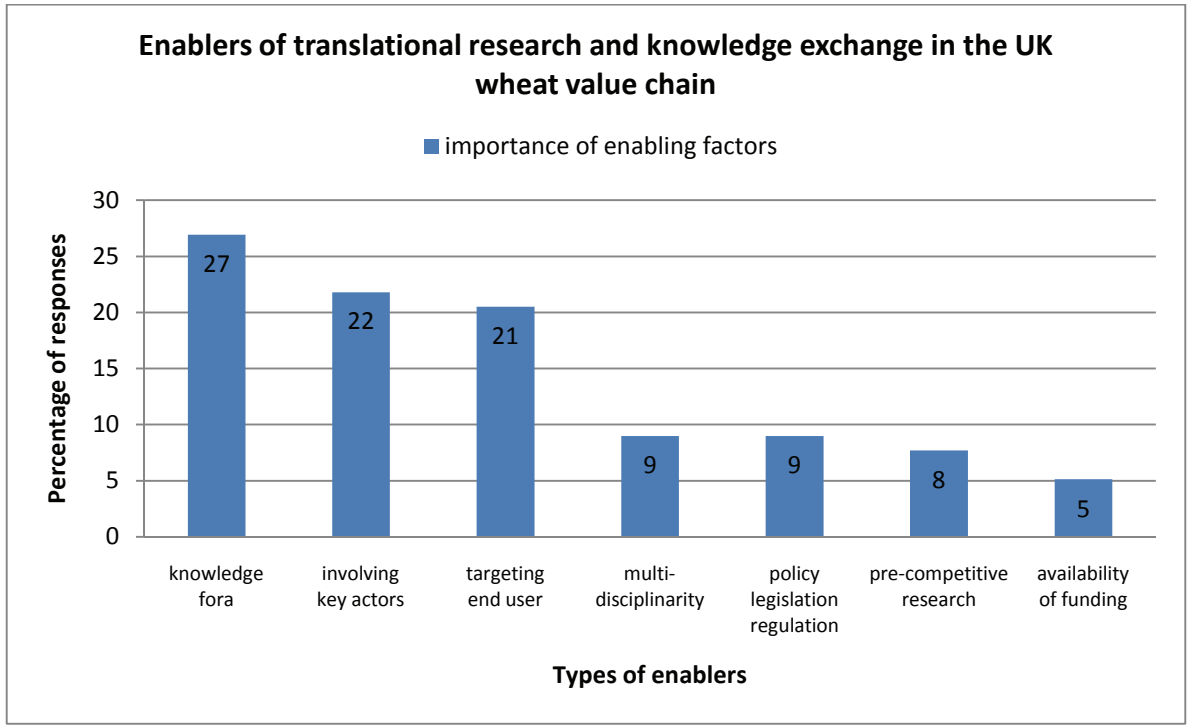


Figure 5-3 Comparison of the importance of different enabling factors (based on the percentage of cited responses) for translational research and knowledge exchange in the wheat value chain

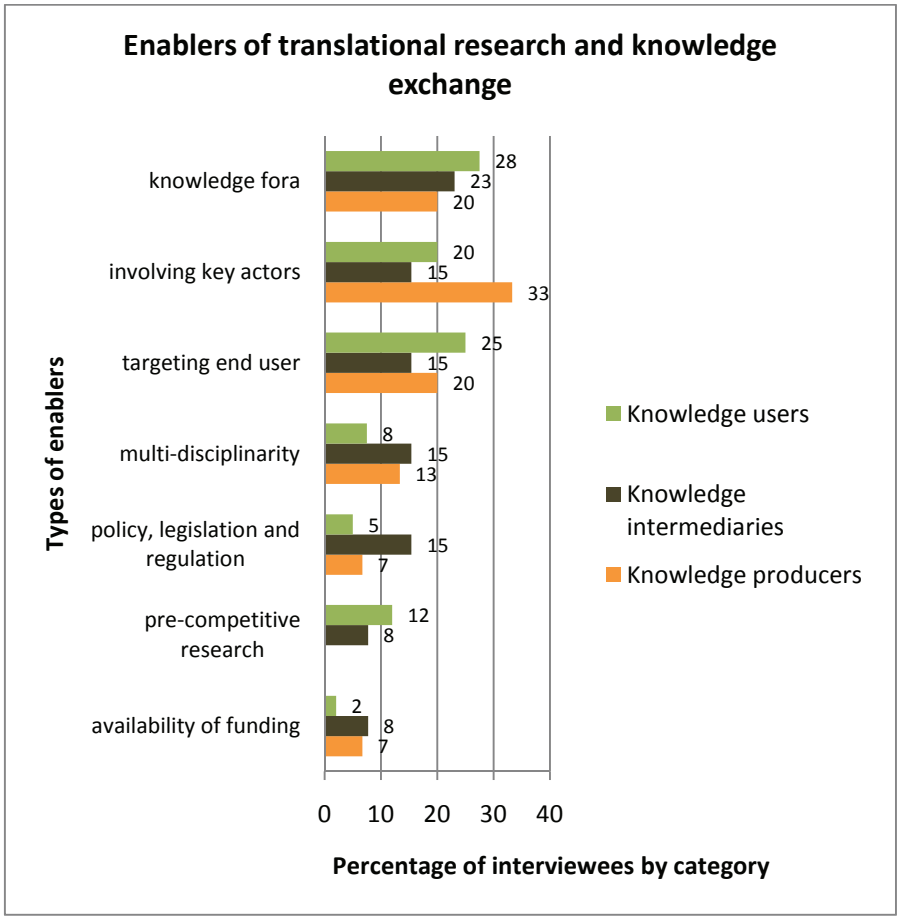


Figure 5-4 Comparison of the importance of different enabling factors for translational research and knowledge exchange by actor and across actor categories

The enabler of knowledge exchange and translational research that was most cited was the existence of fora to facilitate knowledge exchange and translational research and to offer a synthesis of existing knowledge on specific topics. This appeared to be related to a strong theme of fragmentation and in this instance efforts to bring cohesion were welcomed. Interviewees were sceptical about the extent to which the internet could be used effectively to create knowledge fora and some comments about this confirmed the preference for face-to-face communication. One interviewee said:

> "Putting stuff on the internet or putting stuff out on paper doesn't work. Best way of dealing with knowledge exchange is face-to-face at events, conferences, research centres, farm walks, etc. Running good quality events really gets the discussion going and enthuses people."

Comments about knowledge exchange fora indicate the importance given to communication and thus to knowledge exchange and a number of interviewees saw communication, knowledge exchange and translational research as complementary. The following quote shows how one interviewee framed the issue:

> "Collaborative approaches are the primary way the wheat supply chain gathers information. Panels, forums are fundamental for this. Project work that is undertaken is bought into by everybody – even if it doesn't directly affect your

> own activity, you can be aware of it and support it. Even if the R&D takes 3 years to complete, by the time it comes to an end, it is much easier to implement the new technology/product because everyone is aware of it, has engaged with it, and has understood it from concept through to end point."

Issues of communication also relate to the importance of keeping the end user in mind and the importance of involving key actors (and particularly growers) in translational research. Figure 5-3 shows that targeting end users across the value chain is viewed as a significant enabler. It is interesting to note that, as shown in Figure 5-4, these three enablers (knowledge fora, involving key actors and targeting end-users) were viewed as the most important by all three categories of actor (knowledge producers, intermediaries and users) This would seem to indicate a relatively high level of awareness of the importance of communication across the value chain for enabling translational research.

Earlier in the report, however, we showed that learning from others was not seen as a direct motivator for engagement in knowledge exchange and translational research, particularly by knowledge producers. It may be that widely shared examples of how upstream actors, end users and downstream actors can learn from each other in research and product development might contribute to a more cohesive understanding of how communication can enhance knowledge exchange and translational research activities. Figure 5-3 and Figure 5-4 show that although regulation is seen as an enabler, it is viewed as relatively less important one in comparison to knowledge fora, involving key actors and targeting end-users[46]. One interviewee spoke about the European legislation being an enabler in the following terms:

> "Some EU directives did a tremendous amount in terms of bringing everybody in the country up to the same sort of level in terms of how they approached hazard analysis and critical control points."

Another interviewee went on to say that:

> "Some KT (knowledge transfer) is driven by policy e.g. mycotoxin work was driven by European legislation determining minimum standards for mycotoxins in grain. So there are significant policy drivers. Much of HGCA's work on agro-chemicals is also informed and driven by changes in legislation – which generally means that there are fewer chemicals available or that chemicals being used are under threat of being withdrawn and so HGCA has to respond to this by providing a baseline of scientific evidence that can be used by policymakers or supporting the science that might lead to an alternative or solution."

One interesting aspect of the responses is the relative lack of emphasis on availability of funding as an enabler. This would seem to indicate that availability of funds is not thought of as a priority in enabling knowledge exchange and translational research and, at first glance, this may seem to contradict earlier findings; as detailed previously, some interviewees did view the type of funding that is available as a problem and a number of interviewees were worried that existing funding structures and mechanisms worked against

[46] As noted in Figure 5-1, overall policy and regulation was viewed as the most important barrier for translational research and knowledge exchange.

some actors engaging in translational research. However, problems with existing mechanisms and accessibility do not necessarily mean that interviewees find overall levels of funding a pressing problem and thus there is not necessarily a contradiction here. It is important to recognise that interviewees were not responding to survey questions about lack of funding. If that had been the case the answer may well have been different - if people were asked directly whether lack of funds is a problem they may have been more inclined to say 'yes' whereas in a less structured interview setting, funding did not emerge as the most important enabler.

5.4 Validation workshop

Participants at the workshop were unanimous that the complexity of the wheat value chain and price volatility made it difficult to assess the costs and benefits of engaging in knowledge exchange and translational research. 'Buy-in' would depend on actors being able to see demonstrated benefits.

The existence of specific government policies or commercial opportunities could be important driving forces stimulating innovation. These have generally been lacking up till now with the direction of most policies being anti-innovation advocating reduced emphasis on technology in farming systems. Recent shifts in emphasis from UK government departments (Godfray, H.C. *et al*, 2010; UK Government Office for Science, 2011)may begin to move motivations in a more pro-technology direction but even if successful this will take some time to have a demonstrable impact on, for example, wheat related translational research.

Participants pointed to the importance of skills in enabling knowledge exchange and translational research and pointed to the proposed advanced training partnerships as being relevant to this, quoting a recent study by ADAS (ADAS, 2008) showing a positive relationship between farmer's education and yield (i.e. the more recently educated, the higher the yield).

There was also a lively discussion about the importance of 'end users' at the workshop. An argument was put forward by several participants that the end user knows what the problem is and most of the time knows what knowledge he or she needs to solve the problem. The challenge is to bring end-users more actively into decisions about how to engage effectively in knowledge exchange and translational research in the value chain.

One interesting aspect of the discussion was a realisation that participants were not using the term 'end user' consistently. For some, the end user was the farmer, and for others it was the consumer. These differences in thinking about end users reflected the range of different actors involved in the different sub-sectors (food, feed and biofuels) and further emphasised the fragmentation of the value chain.

The examples in Section 5.5 demonstrate the importance of incorporating the farmer as end user into knowledge exchange and translational research activities. However, they also indicate the complexities in incorporating the priorities of value chain actors who are closer than farmers to consumers.

5.5 Examples of successful and failed translational research and knowledge exchange

The gathering of evidence also led to collecting examples of successful and failed knowledge exchange and translational research. In the remainder of this section, we present examples shared with us during the interview programme – a mixture of successes and failures.

5.5.1 The case of the mycotoxin risk assessment project: a success

Mycotoxins are found in grains that have been attacked by a fungus. These toxins potentially end up in flour, and then in products such as bread and cakes that incorporate this flour. The value chain is therefore very sensitive to any risk of mycotoxin contamination which is a food safety issue. Mycotoxin related research was driven by European legislation that imposed minimum standards for grain contamination, providing an example where regulation supports knowledge exchange and translational research.

Millers put pressure on HGCA to invest in research to quantify the risk and the current levels of mycotoxin contamination in flour. HGCA commissioned an independent assessment of levels of mycotoxins at every harvest and advised farmers on best practice - how to avoid mycotoxins in grain, when to spray, weather conditions that pose high risk, etc.

This led to the development of a risk assessment protocol, a form that farmers could fill in online. When they wanted to sell their grain at harvest they had a formula that provided the purchaser with information about the level of risk of mycotoxin contamination.

The level of take up of this risk assessment by growers was 30% and this was not considered by millers to be satisfactory. HGCA then undertook a campaign on the use of risk assessment, using the farming press. They sold the equipment needed (e.g. rain gauge) and gave away free equipment in some cases, leading to 85% of growers using the risk assessment. This has now been accepted by the millers as an important tool in validating the quality of grain.

The return to this project has been estimated at about £17 million[47]. These positive outcomes across the value chain were achieved by investment in translational research and knowledge exchange activities at the development stage and by communications initiatives to convince farmers that their margins would be protected by adoption of the new tool. The clear focus to this work contributed to its success and measurable achievement.

5.5.2 LINK project FQS 23: investigating wheat functionality through breeding and end use – a story in the making

This project ran from August 2001 to January 2008, with a budget of £1.1 million. The objective was to use novel technologies to search for genetic markers and to understand their roles in determining the processing characteristics of wheat. The related translational research has been open-ended.

[47] For more information about this estimation and the mycotoxin assessment risk work carried out by HGCA, see DTZ (2010). Evaluating the Impact of HGCA Funded Research. Manchester, Comminssioned by the HGCA.

The idea was examined by a Campden-BRI panel composed of industrial representatives, allocated to the varieties working group for further consideration. The purpose of this working group was to bring industries together and explore demand.

The project was led by Campden-BRI and the main academic partners were the John Innes centre, Rothamsted Research and the University of East Anglia, with input from HGCA, the Federation of Bakers and individual milling and plant breeding companies. The project succeeded in generating objective methods of measuring the processing performance of wheat and of determining the genetic control of wheat baking quality and led to the identification of several hundred relevant traits.

However, these outcomes needed further research, both basic and applied, before they could be exploited fully. No further public funding has been allocated to build on these findings and it is not clear to what extent this new knowledge has been or will be translated within plant breeding companies to allow them to bring new varieties to market with better processing performance. It appears that some companies have invested internally to develop this knowledge further but others have not, possibly because they do not have the research capacities to do so, or because the returns do not appear high enough to encourage investment. In this example, pre-competitive work was successful but pre-commercial work has proved harder to translate.

5.5.3 The quality of grain for feed: a partial success

Over the years, HGCA has invested in analysis to identify the quality of grain, including wheat, for animal feed, particularly for pigs and poultry. Some 70% of wheat is grown for the feed market but at the moment there are few incentives for growers to focus on the end quality of feed as there is no discrimination in the product - it is just cheap wheat. However, in the pig and poultry animal feed markets there is a real advantage in using high quality grain as it increases the quality of the animals obtained indicating that the gap is in the middle of the value chain. Therefore, HGCA invested in equipment that can analyse a sample of grain for its feed quality. This technique works and is available for use. However it is not being used and still cannot be used at the farm gate, at the point of sale for the grain. Reasons for this include the fact that the technique has not been validated for on-farm use and that the equipment is expensive. As a result, growers are currently not getting any benefit from producing higher quality grain.

In this case the technology farmers could use to persuade the purchaser that they have produced high quality grain has been developed but has not been taken up. However, the grain processors can use this technology to identify the quality of grain and can produce animal feed of varying qualities for pig and poultry producers and price it accordingly. The processors are benefiting from this technology, but the farmers and growers not. Again, this example draws attention to the difficulties of bringing cohesion to a fragmented value chain and convincing farmers that investment could bring economic benefits.

5.6 Conclusions

The three cases of knowledge exchange and translational research in the UK wheat sector gave examples of the barriers and enablers identified in interviews. Regulation in the mycotoxin case was shown to be an enabler of translational research. However, comments

from interviewees suggested that GM regulation has acted as a barrier to innovation. The importance of developing a shared understanding of the issues, a clear identification of and focus on useful outcomes, the inclusion of end users (farmers and grain purchasers), and development of the capacity to build on pre-competitive outcomes, were all highlighted in interviewee comments and in the examples.

CHAPTER 6

Potential for improving translational research and knowledge exchange in the UK wheat value chain

The matrices we developed to capture information about basic and applied research, collaborative research and near-market testing demonstrate that there is considerable translational research related activity in the UK wheat value chain. Interviewees, grey literature and workshop participants all testify to the numerous knowledge exchange activities and to the importance of trade associations and levy boards such as NABIM, HGCA and Campden BRI in the overall translation process.

Several initiatives have calculated the gross economic impact of knowledge exchange and translational research, showing a good return on investment from research on the wheat value chain[48]:

- DTZ report 'Evaluating the Impact of HGCA Funded Research' (DTZ 2010) estimated the gross economic impact of 6 areas of knowledge transfer by HGCA (ratio 8:1)
- DTZ report 'Economic Impact of Plant Breeding in the UK' (DTZ 2010) estimated the gross economic impact of 12 knowledge transfer projects by the British Society of Plant Breeders (ratio 40:1)
- ADAS report 'An Investigation into the Role and Effectiveness of Scottish Monitor Farms' (ADAS 2008) estimated the gross economic impact of Scottish Monitor Farms (ratio 6.5:1)

However, the evidence from this project suggests that there is scope for improvement, given the barriers to knowledge exchange and translational research and the concerns identified within the wheat sector. Numerous reports from analysts and academics point to stagnation in yield from wheat as an indication that failure to adopt research may be damaging competitive advantage at the business and national levels.

[48] Further examples of successful knowledge translation in the UK wheat sector and of their estimated returns are provided in the UK Cross Government Food Research and Innovation Strategy (UK Government Office for Science, 2010).

Building mainly on the evidence from the last two chapters, in terms of activities and their dynamics, this chapter explores interviewees' views on the potential for improving knowledge exchange and translational research.

6.1 Suggestions for improvements from interviewees

As part of our search for evidence on knowledge exchange and translational research in the UK wheat value chain, we gathered information about potential improvements that would enhance these processes.

Based on our interview programme and the written material collected during this study, we identified nine areas, related to the themes of barriers and enablers, where there is scope for improvement.

- *Pivotal role of growers*. A clearer synthesis of what the costs and benefits associated with knowledge exchange and translational research are for growers, and their closer involvement in knowledge exchange and translational research activities would enable them to use and adapt technologies more effectively.
- *Value chain coordination*. Developing a clearer idea of the implications of change related to knowledge exchange and translational research in one part of the value chain for other parts of the chain would enable better translation.
- *Academic incentive structure*. Changing academic incentives by stimulating and rewarding translational research that is better aligned with practical needs would improve the effectiveness of practical knowledge transfer.
- *Public funding eligibility.* Public sector funding rules could be tailored to allow private sector applicants more flexibility in bidding directly for funding for translational research.
- *Capitalising on opportunities in emerging technological areas*. There is a need to put greater effort into ensuring that scientific and technological advances are supported by government policies in progressing along the value chain, for example GM technology and biofuels.
- *Joined-up policy*. There are considerable potential benefits from a clear and articulated government vision and strategy for agriculture and food. Clear messages about how policies and incentives to innovate are being coordinated to support innovation could greatly encourage translational research and knowledge exchange.
- *Strengthen interaction among key actors*. There is a need to build and consolidate links among actors across the value chain.
- *Information asymmetry*. Information fragmentation is a problem in the wheat value chain. Efforts to communicate information about knowledge exchange and translational research more effectively and coherently could have a positive impact.

- *Near-market testing*. There is a need to Increase pre-commercial near market testing and trialling of products and processes (as opposed to pre-competitive testing).

Figure 6-1 and Figure 6-2 summarise interview responses in the above areas. The improvement theme most cited was the strengthening of interactions among key actors, related to the barriers noted above in the context of the disparate nature of the value chain and cultural and social barriers. It is also related to the suggestion that finding ways to recognise the pivotal role of growers and integrate them into knowledge exchange and translational research activities should be a priority.

Findings reported above also suggested that whilst the need for communication might be widely appreciated, there is a need for two-way learning so that downstream actors are feeding expertise and experience back to upstream actors in addition to the feed-forward of basic research into production (see Figure 3-1). Changing the eligibility for access to public funding for translational research in general, and the need for more near-market testing in particular, were also suggested by many interviewees as areas for improvement. This is consistent with earlier findings about the problems perceived by some interviewees with existing funding mechanisms. In funding translational research the government is bound by national and European rules that place constraints on what can be done with public money. It may be possible for companies to use NGOs in more efficient ways and the operation of levy boards and the private sector might be considered in light of these concerns about near-market testing and research.

These findings also suggest that actors in the wheat value chain may not have sufficient knowledge and understanding of existing schemes and may require additional information about how such schemes can be used to meet their needs.

Concerns about greater policy coherence have already been taken up in recent government policy and are reflected in the Food 2030 report (HM Government, 2010). In the context of a complex value chain where products can move along different value sub-chains, this call for coherence is particularly challenging. Regulation, policies and markets are different for animal feed, food and bio-fuel sub-sectors. Integrated advice that helps farmers and other producers to interpret and respond to regulatory requirements and market signals in these sub- sectors should be a priority.

Surprisingly, given other feedback, reducing the fragmentation in communication efforts does not appear here as a priority for improvement. Strengthening interaction is seen as vital, however, and a key theme of this report is the desire amongst actors in the wheat value chain for enhanced opportunities for direct interaction. Seen in this light there is no contradiction here between the lack of emphasis put on information as opposed to interaction.

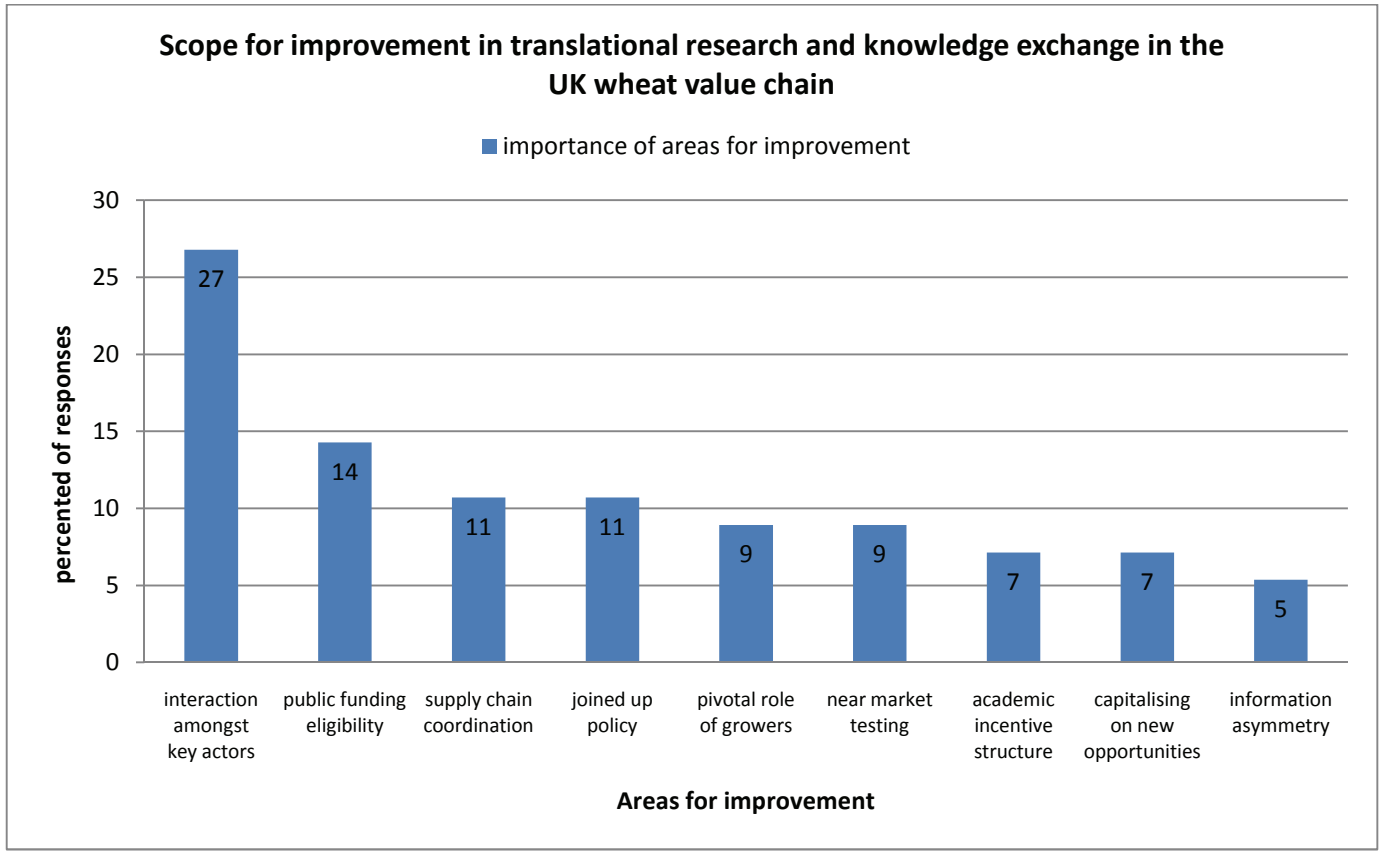


Figure 6-1 Comparison of the importance of different areas for improving translational research and knowledge exchange in the wheat value chain (based on the percentage of cited responses)

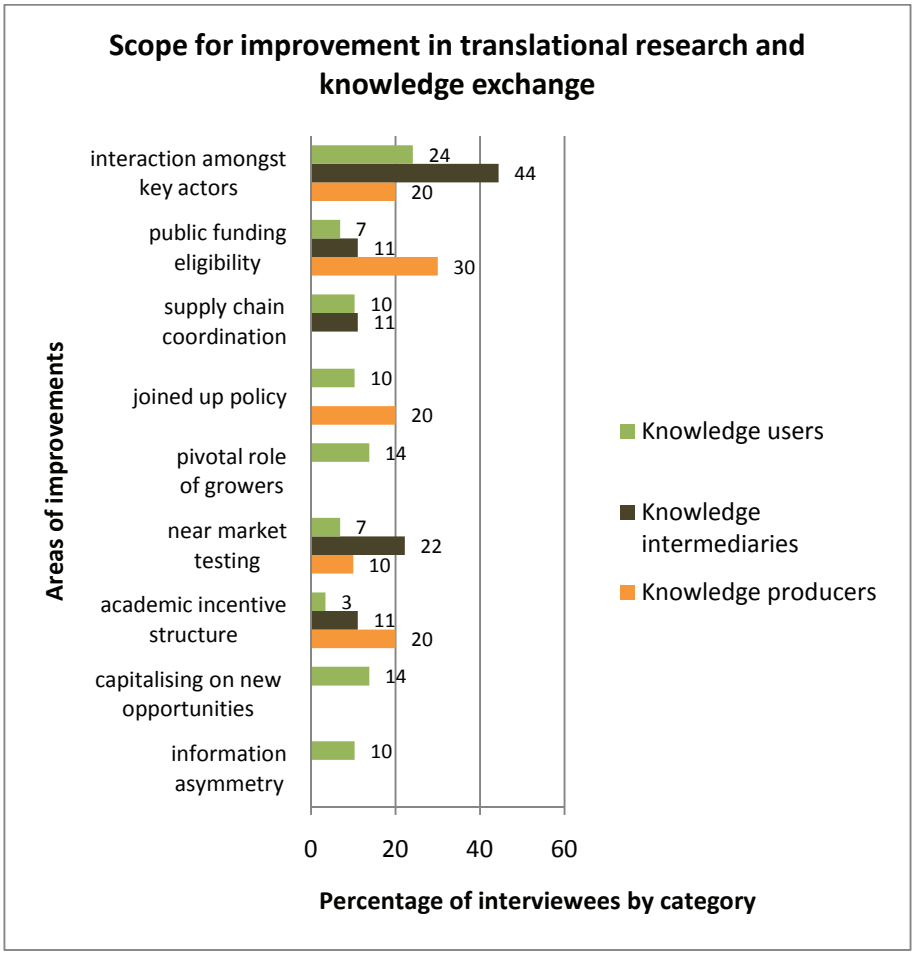


Figure 6-2 Comparison of the importance of different areas for improving translational research and knowledge exchange by type of actor and across actor categories

6.2 Validation workshop

The main observation from the workshop discussion on the potential for improvement was that, overall, translational research and knowledge exchange are taking place reasonably well in the UK wheat value chain.

Focusing on identifying areas where knowledge exchange and translational research are less evident, a number of participants observed that there were 'bottlenecks' or 'pinch points' in the value chain. These would require investment of resources and time to assess in more detail the location of blockages and pinch points and to quantify what is needed to overcome them. A participant from the medical sector referred to the Cooksey report, an independent review undertaken by Sir David Cooksey to advise on the design and institutional arrangements for the public funding of health research in the UK (Cooksey, 2006)[49] as a potential model for a similar initiative for UK agriculture. The question of

[49] The Cooksey report investigates the situation of medical research in the UK and provides a set of recommendations to improve its effectiveness.

whether a knowledge transfer 'czar' could be created to drive forward such a report was also raised.

Another suggestion was to appoint a core group of representatives from the UK wheat value chain (including academics and the industry) to keep track of new knowledge and to assess the costs and benefits and how it could be implemented.

Some participants observed that even after solutions have been identified there are no resources (time, money) to implement the recommendations. Several participants mentioned the recent 'Foresight project' report (Government Office for Science, 2011) and questioned who would take it forward.

Participants suggested that the responsibility and cost of implementation should be shared between the government and the industry, with the government setting the agenda and setting incentives for the industry (e.g. tax credits or penalties for missing targets) and with the industry having an equal responsibility for long-term implementation.

Scope for improvement was also identified related to understanding the economic value of research and innovation and to the need to stimulate knowledge transfer skills through formal training opportunities government could support these through top down initiatives and/or by encouraging organisations to recognise knowledge transfer as part of job descriptions.

6.3 Comparisons with different value chains

At a number of points in this report comparisons have been made between wheat and other sectors. It is worth reflecting a little more on observations made by participants in the workshop about the following differences between wheat, pharmaceutical and pig value chains with respect to knowledge exchange and translational research.

In many health-related sectors, strong intellectual property protection is required to attract the commercial investment needed to take a product through the lengthy and costly development process involving several phases of clinical trials. The same is true for the development of agrochemicals and GM crops. In addition, unlike some areas of health care, wheat itself is a commodity with relatively low but variable profit margins which means that agri-businesses including farmers are more wary of adopting expensive new products. High development costs and low profit margin might account for the relative scarcity of small, research-based companies in the agrochemicals sector (Tait, 2007), thus creating a more difficult innovation environment for the agrochemical industry.

In other parts of agriculture and food-related value chains, such as food processing, commercial value is protected by secrecy around processes and products rather than by intellectual property, and by having a much faster route to market.

Some participants reflected on other value chains in the agricultural and food sectors. The absence of income protection and support by the Common Agricultural Policy (CAP) to the pig sector (as compared to wheat) has meant that the industry has had to fend for itself for longer and has organised itself more effectively. This has led to a lean and adaptable industry where decision-makers have learned to respond quickly to ever-changing trading conditions, and to the complexities of animal welfare legislation and politics. This has

included awareness of the need for rapid incorporation of new knowledge and technologies into farm businesses, leading to the adoption of new genetics, nutrition, reproductive physiology and environmental technologies and management.

In addition to a lean structure, this industry has a highly networked National Pig Association, responsible for industry representation and lobbying. The Association is closely associated with the levy payers body (BPEX) and this creates good conditions for pig producers and consultants working within the industry to be well connected to a range of knowledge exchange and translational research activities across the whole value chain. A workshop participant thought that combining these organisations has played a valuable, indeed essential, role in the determination of new programmes, and that the wheat value chain may be able to learn lessons from the way organisations have worked together in this instance.

One participant observed that large food companies have driven much innovation and change in rye and oats and that this driver seems to be lacking in wheat. Stronger guidance may be needed on directions to be taken for wheat.

6.4 Conclusions: Where do translational research and knowledge exchange add value to the wheat value chain?

Evidence gathered in putting together the matrices indicate significant activity in translational research across the wheat value chain. However, these data were difficult to compile and the matrices are incomplete because we did not have sufficient time and resources to do a comprehensive and exhaustive search. We know from interview data that there is considerable non-collaborative research that is closer to the market carried out by knowledge users. Many workshop participants concluded that, in comparison to other sectors, the level of contributions of translational research and knowledge exchange in wheat is satisfactory. In thinking about where translational research and knowledge exchange contribute along the value chain, the following points are relevant:

- There was no expressed opinion that the overall contribution of UK basic research is lacking although some interviewees thought it to be misdirected. Basic research does appear to add value by laying important foundations for further knowledge exchange and translational research.
- Interview and case study evidence indicates a contribution to downstream knowledge exchange from a range of industry and levy boards. LINK programmes were often mentioned as important (if sometimes flawed) mechanisms for applied pre-competitive research. However, there was evidence that pre-competitive research does not always automatically translate into pre-commercial or commercial knowledge exchange.
- Near-market and pre-commercial aspects of translational research and knowledge exchange seem to be hampered by concerns about confidentiality and competition. More investigation would be needed to gauge the extent and nature of the problem. However evidence gathered here suggests that these concerns may

be preventing more collaborative forms of translational research and knowledge exchange from contributing fully at near-market stages.

The clearest message from this research is that the main barriers to translational research and knowledge exchange relate to the lack of synthesised and useful information, communication challenges and fragmentation of different types of actors across the value chain. This disparity in accessible information across the value chain (termed information asymmetry by economists) causes barriers to translational research because participants are unable to access the information they need for decision-making. This prevents maximum benefit being derived from early stage knowledge generation through knowledge exchange. This suggests that translational research could add more value by improving existing knowledge exchange activities so that they address the specificities of the wheat value chain more effectively.

Face-to-face meetings were considered an important means to overcome fragmentation amongst actors along the value chain, including the farming community. This fragmentation limits the extent to which translational research can effectively contribute to improving products and processes. Existing knowledge exchange activities should be re-thought in light of the evidence presented here about the specificities of the wheat value chain. Additional knowledge exchange tools could perhaps be devised so that the benefits of one-to-one consultations are more widely spread, perhaps by feeding into on-line or printed 'frequently asked questions'.

Barriers to translational research are also found in fragmentation, blockages and lack of information. In terms of the analysis in section 3.3.2 the problem lies less in the nodes and more in communication and iteration between nodes[50].

[50] Richard Nelson, a well-know innovation economist, points out in recent work that the mix of actors and the way they discuss division of tasks and communicate between themselves about the development of technologies and products is as vital to innovation as the scientific and technical developments.

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APPENDICES

Appendix A: Additional detail on the methodology

This study had the clear objective of being evidence-based. In this chapter we summarise our search for evidence relating to knowledge exchange and translational research in the UK wheat value chain.

Review of literature and other written material

For the search of literature and other written material, we considered peer review literature and other publications, referred to as grey literature. Below we summarise the process and the outcomes of our efforts.

Peer-reviewed literature

We use the Web of Science database to carry out a search of peer review literature on the topics of knowledge translation and knowledge exchange in the UK wheat sector. We carried out two searches. Below we present each of these searches: we briefly describe the search steps and then we present the outcomes of this search and interpret them.

Basic searches on the Web of Science publication database: The first search aimed at comparing the outcomes of several basic searches between agriculture/wheat and medicine, with as well as without geographic constraints. We used Web of Science as it is one of the leading and most comprehensive databases. Besides sector and geography, the terms used for these basic searches were 'translational research' and 'knowledge exchange'. The outcomes of this search are presented in the table below.

Table A-1 Web of Science search outcomes

Group	Number of publications (restricted to UK)	Number of publications (not restriction to UK)	Topic
Group 1	29	n/a	See search terms defined in Group 1 below
Group 2	0	3	*Translational research* and Wheat
	0	4	*Translational research* and Agriculture
	10	817	*Translational research* and "Health Sector"
	0	0	*Knowledge exchange* and Wheat
	2	13	*Knowledge exchange* and Agriculture
	5	71	*Knowledge exchange* and "Health Sector"

Source: RAND Europe

The literature search process involved the definition of search terms as follows:

Group 1: contained 11 sets of search terms, which deliberately excluded the terms translational research and knowledge exchange – the aim was to capture material that relates to these concepts, but does not explicitly use them (the terms are relatively new to agriculture or at least not in frequent use). This resulted in 29 publications most of which are about mycrotoxins and traceability issues.

Group 2: contained 12 sets and here the focus was on translational research and knowledge exchange in wheat and more broadly agriculture (8 sets), and for comparative purposes on translational research and knowledge exchange in health (4 sets).

Table A-2 Definition of terms relating to the concepts of translational research and knowledge exchange

Group 1: Definition of search terms that related to but do not use the terms translational research and knowledge exchange in the wheat value chain
1. Topic=(("pre$competitive research" OR "pre$commercial research") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
2. Topic=((pre$competitive OR pre$commercial) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
3. Topic=(("knowledge exchange" OR "knowledge transfer" OR "collaborat* research" OR "extension servic*" OR "joint ventur*" OR knowledge OR "knowledge flow" OR "knowledge generation" OR "knowledge production" OR innovation OR information OR "information flow" OR dissemination activities) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
4. Topic=(("supply chain" OR "food chain" OR "value chain" OR "knowledge chain") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
5. Topic=((grow* OR mill* OR bake* OR "grain merchant*" OR "agr* chem*" OR "plant breed*" OR "feed compound*" OR "animal feed" OR bio$fuel OR "food manufac*" OR retail*) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
6. Topic=((legislat* OR regulat* OR "food standard*") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
7. Topic=(("farm* system*" OR "farm* management") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
8. Topic=((skill* OR "skilled labour*" OR "skilled workers" OR "labour mobility") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
9. Topic=((produc* OR profit*) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
10. Topic=((productivity OR profit*) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
11. Topic=(("food manuf*" OR retail*) AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))

Table A-3 Definition of terms with direct reference to translational research and knowledge exchange

Group 2: Definition of search terms for translational research and knowledge exchange in the wheat value chain
1. Topic=("knowledge exchange" AND wheat) 2. Topic=("knowledge exchange" AND (wheat AND (UK OR "united kingdom" OR "great britain" OR britain OR England OR Wales OR Scotland OR "Northern Ireland"))) 3. Topic=("knowledge exchange" AND agriculture) 4. Topic=("knowledge exchange" AND (agriculture AND (UK OR "united kingdom" OR "great britain" OR britain OR England OR Wales OR Scotland OR "Northern Ireland"))) 5. Topic=("translational research" AND wheat) 6. Topic=(("translational research") AND (wheat AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland"))) 7. Topic=("translational research" AND agriculture) 8. Topic=(("translational research") AND (agriculture AND (UK OR united kingdom OR great britain OR britain OR England OR Wales OR Scotland OR "Northern Ireland")))
Group 2: Definition of search terms for translational research and knowledge exchange in health
1. Topic=("translational research" AND (medicine OR health OR pharm* OR "pharm$ industry")) 2. Topic=("translational research" AND (medicine OR health OR pharm* OR "pharm$ industry") AND (UK OR "united kingdom" OR "great britain" OR britain OR England OR Wales OR Scotland OR "Northern Ireland")) 3. Topic=("knowledge exchange" AND (medicine OR health OR pharm* OR "pharm$ industry")) 4. Topic=("knowledge exchange" AND (medicine OR health OR pharm* OR "pharm$ industry") AND (UK OR "united kingdom" OR "great britain" OR britain OR England OR Wales OR Scotland OR "Northern Ireland"))

Grey literature and other written material

For this study we considered, as requested by the call for tender, various other sources of written material, whether published or not. This included publications from the organisations listed in the call for tender, publications or written material recommended by stakeholders, partners, or circulated by the Defra and BBSRC steering group.

We looked at reports and publications from

- The FRP International sub-group study on wheat (which will be in progress at the time as this project)
- Defra reports and studies on knowledge exchange and translation in wheat
- TSB/ Bioscience KTN studies
- Other work that may be being undertaken in the UK
- BBSRC, Defra and other funded awards focused on wheat
- The work of wheat-linked networks such as Defra-funded WGIN
- Levy bodies and other such organisations

- Impact of new regulations

We gathered further literature and written material through own search as well as part of engaging with stakeholders during the interview programme and the validation workshop.

We looked at website of stakeholders and of actors identified as active in knowledge exchange and translational research.

We looked at existing online libraries specialised on agriculture and food issues are provided by organisations whose mission includes knowledge transfer or knowledge exchange aims. They gather a large amount of written material of various natures, from peer reviewed literature to non-reviewed publications and other written material of interest – playing a useful supplementary role to peer review publication databases.

We explored the OpenFields library, which has been developed from the work of the National Rural Knowledge Exchange (a HEFCE funded collaboration between 14 universities) and is currently supported and hosted by Harper Adams University College[51][52]

We followed up the Web of Science work with The OpenFields online library offers a search facility. Here is the outcome of our search on this online library:

[51] The 'library' has the capacity to bring together a large number and a wide variety of knowledge transfer items - text documents, images, audio and video, and provides direct access to each without charge. Items are contributed by and via organisations whose mission is to promote best practice, knowledge exchange and transfer: colleges; universities; professional and learned bodies; industry initiatives. For more information and access to the library, use http://www.openfields.org.uk/Library/home/Default.aspx

[52]Our attention was also drawn to CAB Direct: CAB Direct has been developed by CABI, not-for-profit international organization; it offers extensive source of reference in the applied life sciences, incorporating the leading bibliographic databases.
CABI is a not-for-profit international organization that improves people's lives by providing information and applying scientific expertise to solve problems in agriculture and the environment. Its mission and direction is influenced by our member countries who help guide the activities it undertake. These include scientific publishing, development projects and research, and microbial services.

http://www.cabi.org/
Its online library can be accessed via the link: http://www.cabdirect.org/

Table A-4 OpenFields library search

Search terms	Number of technical and business information (last 5 years)	Number of research papers and abstracts (last 5 years)
"translational research" AND wheat	1	0
"knowledge exchange" AND wheat	2	2
"knowledge exchange" AND agriculture	8	3
UK *agriculture* Knowledge exchange	22	12
UK *agriculture* translational research	1	0
UK Wheat Knowledge Exchange	5	3
England Wheat Knowledge Exchange	4	3
Scotland Wheat Knowledge Exchange	4	2
Wales Wheat Knowledge Exchange	3	1
GB Wheat Knowledge Exchange	0	1
UK Wheat *translational research*	1	0
UK Wheat *extensive service*	0	5
UK Wheat *collab* research*	8	3
UK Wheat *knowledge transfer*	9	7

Source: RAND Europe

The outcome of this search efforts shows that there is very little material discussing translational research and knowledge exchange in the UK wheat sector. Furthermore, there is little mention of translation research with respect to UK agriculture sector more generally. However, there are relatively more publications referring to knowledge exchange in relation to the UK agricultural sector[53].

Economic reports and data on the wheat value chain

We searched for economic data and statistics, in particular for recent report describing the entire wheat value chain from an industrial economic point of view.

We found that data and statistic about the UK cereal industry are available at various places, especially on the Defra site, the HGCA site, and trade association websites as well as on some the websites of international organisations, including the European Commission (Eurostat). It is interesting to note that many of the statistics and data refers to the cereals as an aggregate and that data and statistics specifically on UK wheat sector are not available to the same degree.

We looked for detailed economic reports on the UK wheat value chain, describing the sequence of markets forming the wheat value chain (number of firms and size distribution, concentration, price mechanism, types of products, type of competition, dominant advertising strategies, dominant R&D strategies, vertical agreements in place, main regulatory regimes in effect, etc).

No recent detailed wheat industry report describing the entire UK wheat value chain could be found in the public domain through some searches on the web or through requests to

[53] Due to the relatively new usage of the terms 'translational research' and 'knowledge exchange', the search for evidence entailed very detailed analysis and systematic extraction of the specific information that relate to translational research and knowledge exchange, but which did not make use of the terms. The aim was to capture material that related to these concepts, but did not explicitly use the terms.

stakeholders knowledgeable on the economics of the UK wheat value chain.[54] The report more closely related to our interest is the Report of Cereal Industry Review commissioned by HGCA (Turner 2004) and the Structure of the UK cereals and oilseeds industries – report for the Home Grown Cereals Authority prepared by the Rural Business Unit of the University of Cambridge (2002) . Specialist reports on specific segments of the UK cereals value chain are available for a fee from market research and consultancy firms.[55] However it was not possible to establish to what extent reports describing the entire UK value chain would be available.

Interpretation of findings

The above description of our search for evidence leads to the following observations:

- Significantly more grey literature exists than peered review literature;
- Scattered and fragmented information relating to translational research and knowledge exchange in the UK wheat sector; this information is scattered across the different actors involved; this creates a significant risk of not being exhaustive;
- Due to the nature of the translational research and knowledge exchange activities, with many of them informal, and with some of them viewed as confidential evidence on these activities is not systematically recorded in written material or is no put in the public domain; this adds to the risk of missing relevant information;
- Variation in the ease with which relevant information can be found on the various actors' websites; this further contributes to the risk of not gathering the relevant information.

[54] Our efforts to locate an economic and business description of the UK wheat value chain focused on asking stakeholders active in various part of the UK wheat value chain, including: HGCA (Jack Watts), ACI (Paul Rooke), EFFP (Sion Roberts), ESCR (Paul Rouse), RELU (Philip Lowe), NFU (Guy Gagen) and Defra (Keane Courtney).

[55] See for example, the webpage of IBISWorld advertising a UK industry report on grain milling product published in September 2010; http://www.ibisworld.co.uk/industry/default.aspx?indid=564#Contents

Appendix B: List of interviewees in the UK wheat value chain

Table B-1 Interview list of knowledge users, knowledge intermediaries, knowledge producers and knowledge funders

Users of Knowledge (24)
Growers (Self employed farmer, Self employed farmer/HGCA, Co-op farms, Self employed farmer) **Millers** (Allied Millers, Heygates) **Bakers** (Rank Hovis Ltd) **Merchants** (Co-op, Camb Grain, Aberdeen Grain/Open Field) **Agri-Chem** (BASF, Limagrain, BEP Certis) **Plant Breeders** (Senova, Monsanto, RAGT Seed) Feed (AB Agri) **Bio-Fuel** (Biocaldol, Vivergo, British Sugar) **Food Manufacturers** (HJ Heinz Ltd, Weetabix, Tetra Pak) **Retailers** (M & S, Sainsbury's)
Intermediaries of Knowledge (8)
Private KTN (Food Processing Faraday) **Levy** (HGCA) **Consultants (Bio-Rationale)** **R&D organisation** (Campden – BRI, ADAS) **Agri Consultants** (Velcourt, Prime Agriculture)
Producers of Knowledge (8)
HEIs (Nottingham, SAC, Reading, RAC) **Institutes** (FERA, Rothamsted Research, NIAB)
Funders of Research (5)
Research Councils (BBSRC) **NGOs** (Gatsby, WWF) **TSB** **Defra** **RTC- CRIC**

Appendix C: List of workshop participants

The validation workshop took place on 8 February 2011. It included the following participants:

Table C-1 List of workshop participants

User of knowledge
Farmers **Feed compounders** (Thompson) **Bio-fuel** (Ensus, Vireol) **Sprays** (Bayer-Crop Science) **Plant breeders** (KWS UK Ltd) **Food manufacturers** (Nestle, Jordans) **Agriculture equipment and machinery** (European Society of Agricultural Engineers)
Producer of knowledge
Universities (Harper Adams University, Cranfield University)
Intermediaries
Agronomic consultant (AICC) **KTN** (Bioscience KTN) **Trade association** (NABIM, AIC) **Levy body** (HGCA) **R&D organisation** (Campden-BRI) **Employer Federation** (NFU)
Funders of research
Funding agencies (TSB, BBSRC, NERC, Integrative Biorefining Research and Technology Club (IBTI club)) **Government department/agency** (Defra, FSA)
Other sectors
Medical (Enteric, South West Peninsular CLAHRC) **Poultry** (Aviagen) **Pig** (BPEX)

Appendix D: Background description of project on improving protein content of wheat

Box D-1 Developing tools to predict the protein content of bread making wheat to better manage fertiliser application – LK0990 (MALNA 2)

Developing tools to predict the protein content of bread making wheat to better manage fertiliser application - LK0990 (2007-2010)
Description SA432 Predicting grain protein to meet market requirements for breadmaking and minimise diffuse pollution from wheat production This project aims to improve the efficiency of decision making with respect to applications of fertiliser nitrogen to milling wheat. The approach will be to use a crop modelling approach, combined with NIR sensing of crop nitrogen content between growth stages 61 and 73, to predict final grain protein content and grain yield. The results will allow growers to target inputs of late applied foliar urea to milling wheat crops. The aim will be to identify those crops where application of FU is not needed, and thereby saving input costs, and similarly, those crops where application of FU would be advantageous in meeting the market requirements for wheat at 12.5% for export and 13% protein for UK millers. The objectives will be to: 1. Develop a model to predict final grain yield and protein content 2. Test the model with growers and grain cooperatives using commercial crops 3. Provide reference dataset to test physiological aspects of model 4. Validate and improve previous NIR calibrations for N% and moisture in immature material and grain 5. Validate overall grain yield and grain protein forecasting model The project will test the prediction system with up to 60 commercial growers over three seasons. Samples will be collected by growers and delivered to two central locations (grain cooperatives) equipped with NIR machines. Specific experimentation will be carried out to test the underlying hypotheses used in the model regarding physiological aspects of nitrogen partitioning within the crops. Field experiments will also generate reference samples to improve the underlying NIR calibrations for nitrogen and moisture content in immature material, developed during the previous MALNA LINK project.
Contractor / Funded Organisations Home Grown Cereals Authority, Heygates Ltd, ADAS UK Ltd., Fengrain Ltd, Campden Technology Ltd, Camgrain Stores Ltd, Bruker Optics Ltd

Source: Defra website
http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=14724&FromSearch=Y&Publisher=1&SearchText=LK0990&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

Box D-2 Prediction of wheat protein – LK0927 (MALNA 1)

Prediction of wheat protein - LK0927 (2002-2006)
Description Optimising nitrogen fertiliser inputs to achieve the quality requirements of breadmaking wheat for maximum return, remains a challenge for the grower. This 4 year project aims to produce a fast and effective on-farm method of predicting grain protein content and quality, at or before the milky-ripe development stage, which will allow accurate late N decision-making. This will be achieved through 1) the development of portable FT-NIR (Fourier Transform near infrared) instrumentation for analysing whole immature grain 'on-the farm'; 2) the provision of robust NIR calibrations using data from trials of winter wheats, managed by ADAS-Boxworth, conducted at several sites over three seasons with a range of nitrogen fertiliser rates. The protein content and a number of established quality-related parameters will be measured in the mature grain samples. Novel biophysical (FT-IR and FT-Raman spectroscopy) and biochemical techniques will be employed to examine the relationship between assembly of glutenin polymers during development and end-use properties of grain. This will provide a better understanding of how the interaction of genetic factors and growth conditions influence the quality of breadmaking wheat, as well as the NIR spectral data used for monitoring developing grain. The key benefits are as follows: • The project will provide farmers with the means to assess the late N need of growing crops and applying late N fertiliser where benefit can be gained. • The provision of a fast and reliable means of predicting grain protein content and breadmaking quality at or before GS70-75, when late N fertiliser may still be applied effectively. • A risk management tool for farmers to improve their ability to meet high quality wheat targets consistently, thus improving marketability and the sustainability of the UK arable and milling/breadmaking industries. • Improved efficiency in the use of late N for grain protein and quality will provide significant financial and environmental benefits through reduction in late N fertiliser use.
Objective 1) To understand the basic science underlying the relationship between growth conditions, developmental stages, grain N and protein composition and NIR spectra. 2) To develop a rapid FT-NIR method for the analysis of immature whole grain samples for predicting wheat protein content at harvest. 3) To develop a rapid FT-NIR method for the analysis of immature whole grain samples for predicting breadmaking quality-related parameters at harvest. 4) To provide a rapid on-farm measurement method, that is practical and be accessed cost-effectively. 5) To provide an objective decision support system which will help avoid the uneccessary or inappropriate use of late N fertilisers.
Contractor / Funded Organisations Home Grown Cereals Authority, Campden Technology Ltd, Heygates Ltd, ADAS UK Ltd., Rothamsted Research (BBSRC), Bruker Optics Ltd

Source: Defra website
http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=10901&FromSearch=Y&Publisher=1&SearchText=LK0927&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description

Appendix E: Developing and maintaining the evidence base of the UK wheat value chain

The evidence based developed in this project can be maintained as an on-line archive. The contents of the spreadsheet might be stored on a website that would be accessible through a search tool. The figure below provides a snapshot of detailed evidence on translational research and knowledge exchange that was collected during this study.

Table E-1 A snapshot of actor-activities detailed information

	A	AM	AN	AO	AP	AQ	AR	AS
1	Activities →	food science and food safety						organic agricultur
3	Actors ↓		Activities/funded projects	Theme/field	Contractor/collaborator/sponsor	Source	Link	
37	Research Councils							
38	BBSRC							
39			Transgenic wheat used as a tool to study the relationship between the spatial patterns of gluten protein gene expression in the grain, the pathways of gluten protein trafficking and deposition and grain processing	The relationship between patterns of gluten protein synthesis and deposition and grain processing quality: a transgenic approach	Rothamsted Research	BBSRC website : Accessed 07/12/2010	http://oasis.bbsrc.ac.uk/netans-bin/gate.exe?f=doc&state=q2cr1p.1.10	
40			Generation, characterisation and exploitation of variation in starch properties in barley and wheat	The Smart Carbohydrate Centre	John Innes Centre, Aberystwyth University and National Institute of Agricultural Botany	BBSRC website : Accessed 07/12/2010	http://oasis.bbsrc.ac.uk/netans-bin/gate.exe?f=doc&state=q2cr1p.1.40	
41			to develop new wheat genotypes with enhanced soluble fibre composition of flour to improve its nutritional properties	Manipulation of cell wall synthesis to improve the dietary fibre composition of wheat flour	University of Cambridge and MRC Centre Cambridge	BBSRC website : Accessed 07/12/2010	http://oasis.bbsrc.ac.uk/netans-bin/gate.exe?f=doc&state=q2cr1p.1.69	

The above information may be periodically updated and stored on a webpage for access and shown below.

Translational Research Database

Cereal | Dairy | Horticulture

This search tool provides a flexible search options for accessing Projects that contribute to translational research in the UK agricultural sector...

Enter your Text Search: AND | All these words | | All these fields

Appendix F: Analysis of translational research and knowledge exchange by knowledge users, intermediaries and producers

The interview results of translational research and knowledge exchange are presented in this appendix in separate bar graphs for each of the three categories that were analysed (knowledge users, knowledge intermediaries and knowledge producers). The fall under 6 categories:

- Modes of knowledge exchange
- Modes of translational research
- Motivations for engaging in translational research and knowledge exchange
- Barriers to translational research and knowledge exchange
- Enablers of translational research and knowledge exchange
- Scope for improvement in translational research and knowledge exchange

Modes of knowledge exchange

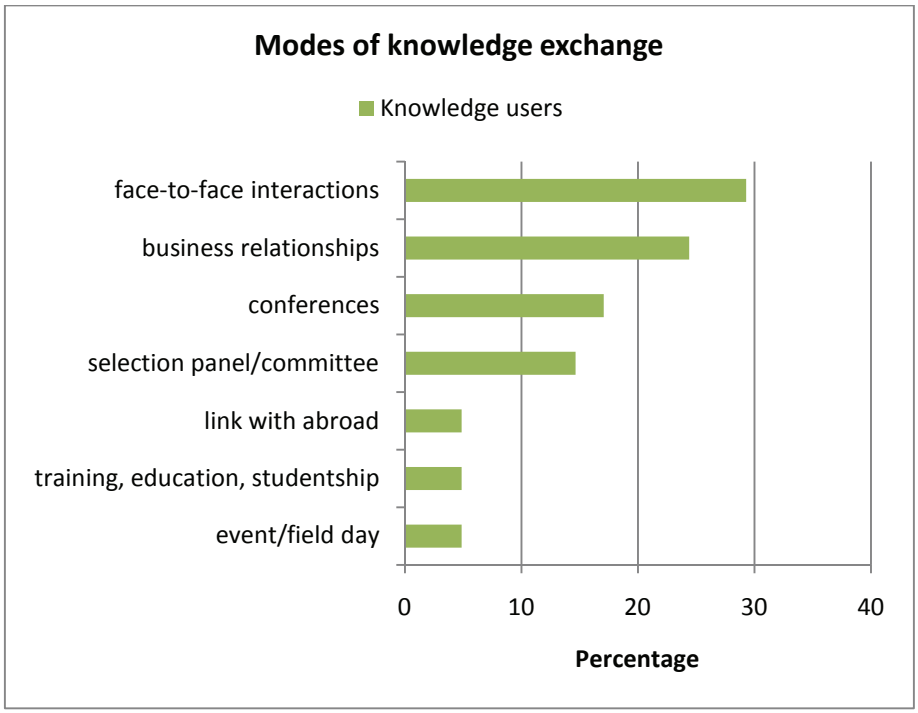


Figure F-1 Knowledge users' mode of knowledge exchange

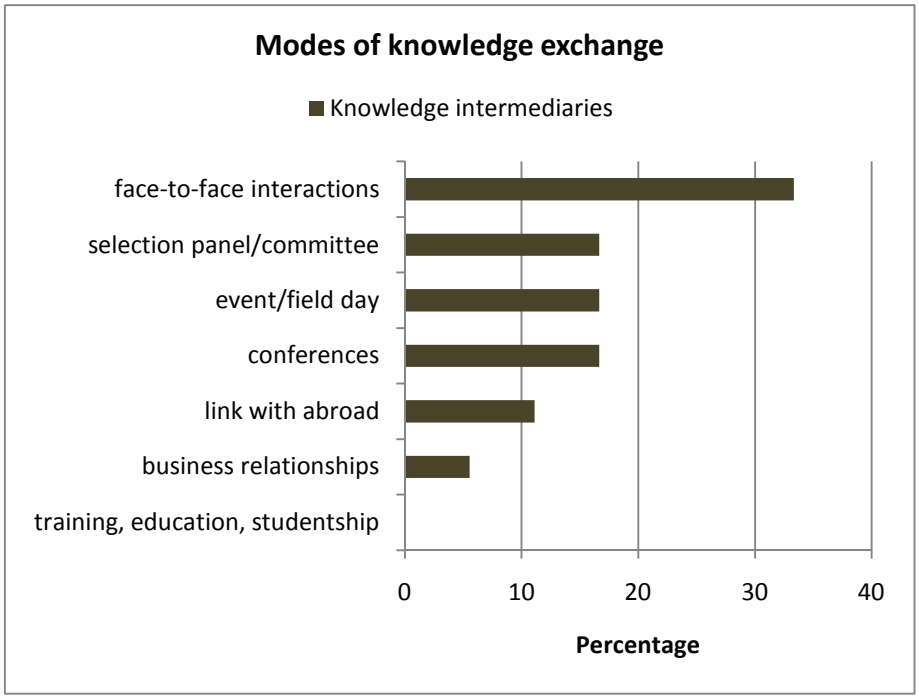


Figure F-2 Knowledge intermediaries' modes of knowledge exchange

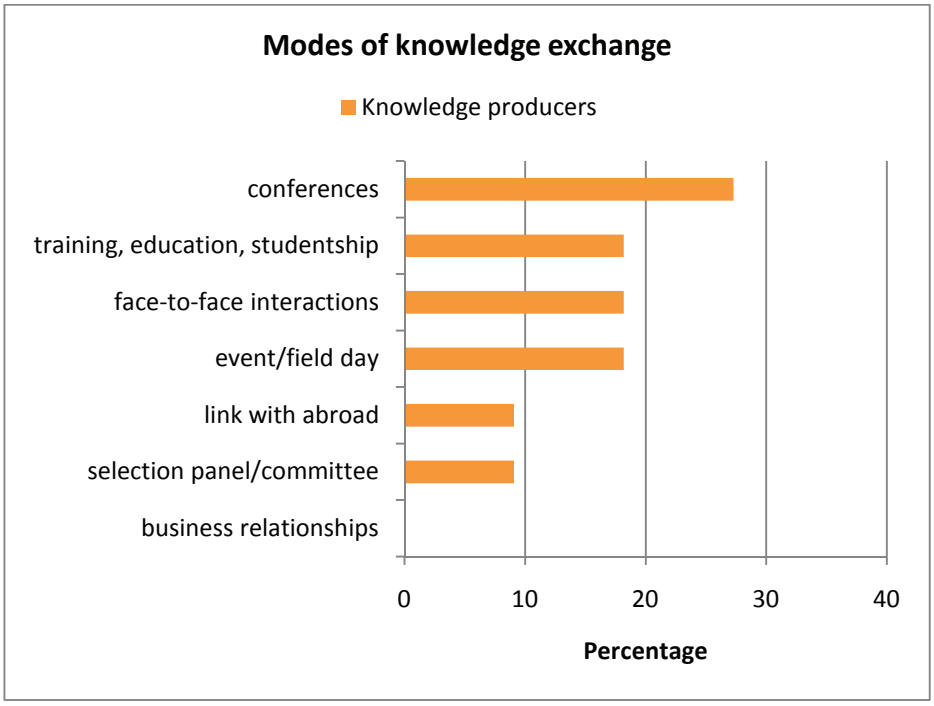


Figure F-3 Knowledge producers' mode of knowledge exchange

Modes of translational research

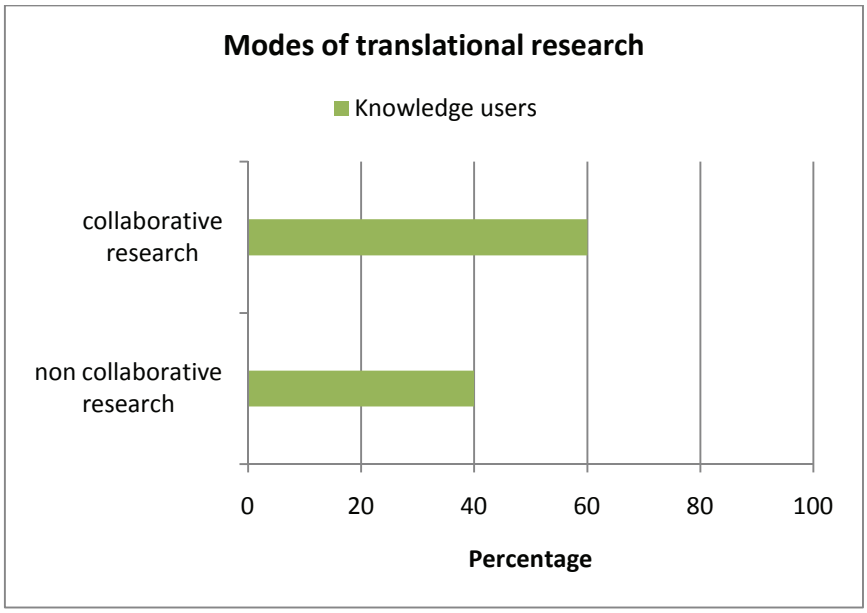


Figure F-4 Knowledge users' modes of translational research

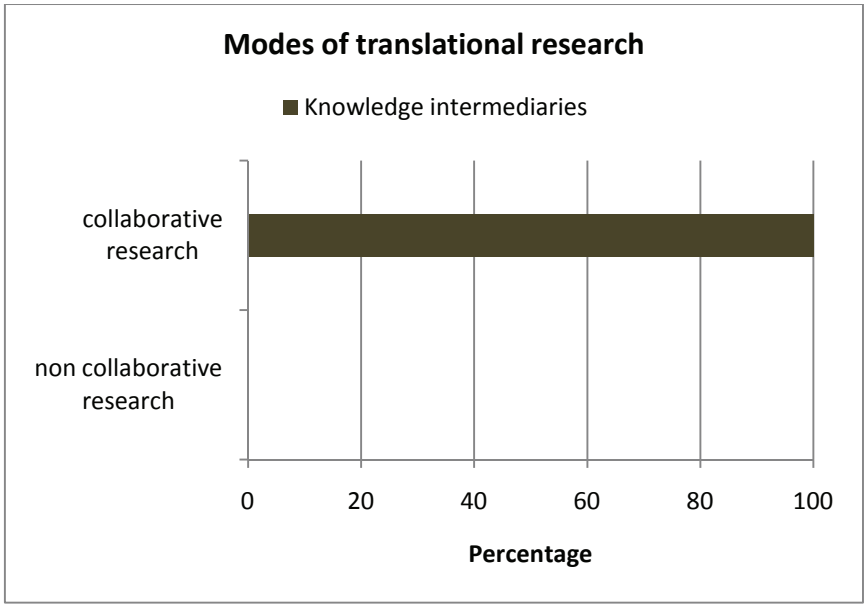


Figure F-5 Knowledge intermediaries' modes of translational research

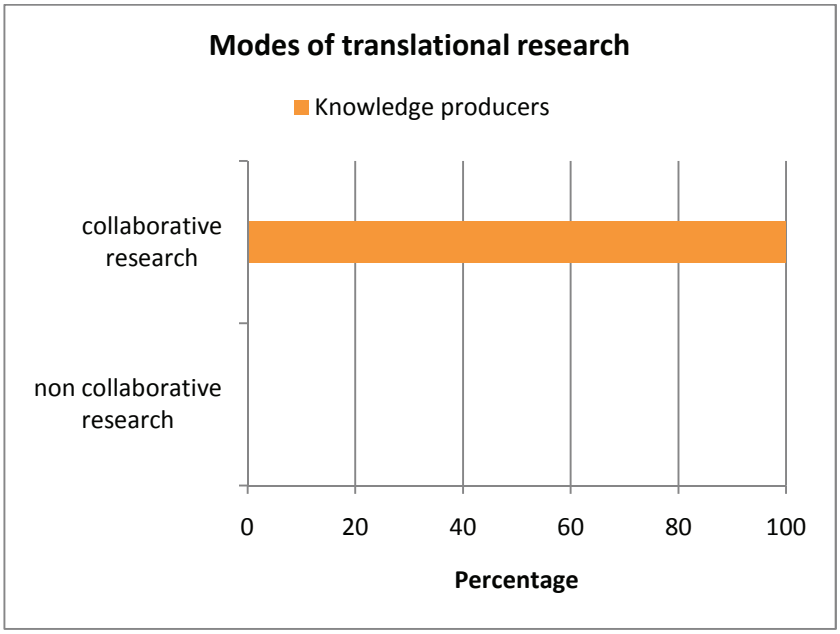


Figure F-6 Knowledge producers' modes of translational research

Motivations for engaging in translational research and knowledge exchange

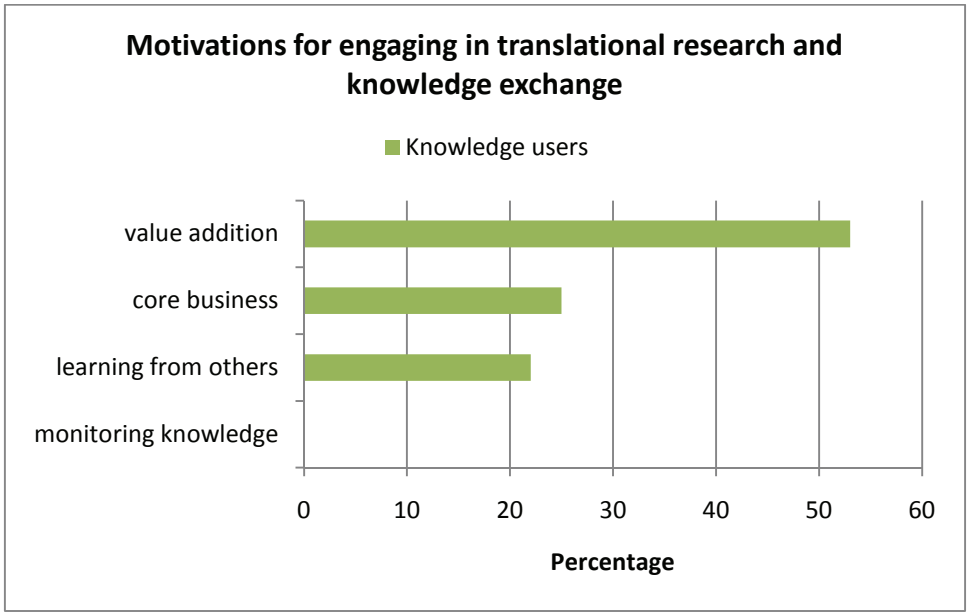


Figure F-7 Knowledge users' motivations for engaging in translational research and knowledge exchange

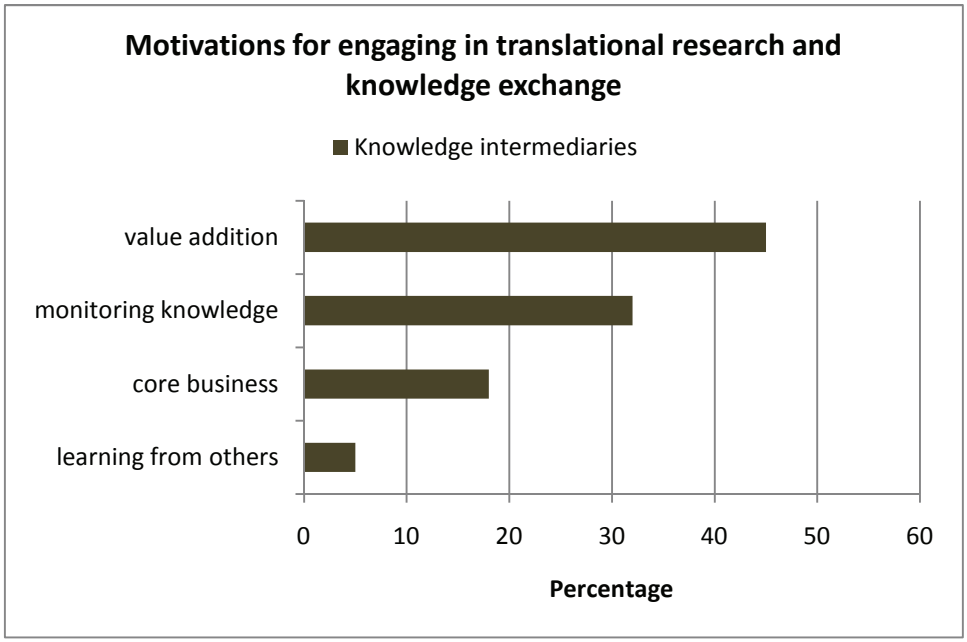


Figure F-8 Knowledge intermediaries' motivations for engaging in translational research and knowledge exchange

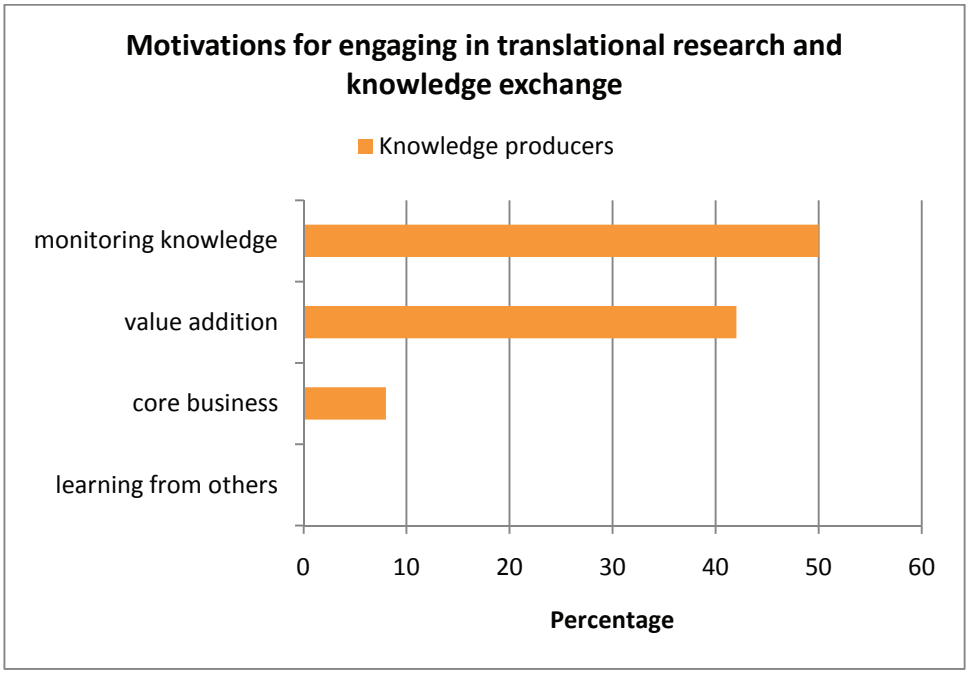


Figure F-9 Knowledge producers' motivations for engaging in translational research and knowledge exchange

Barriers to translational research and knowledge exchange

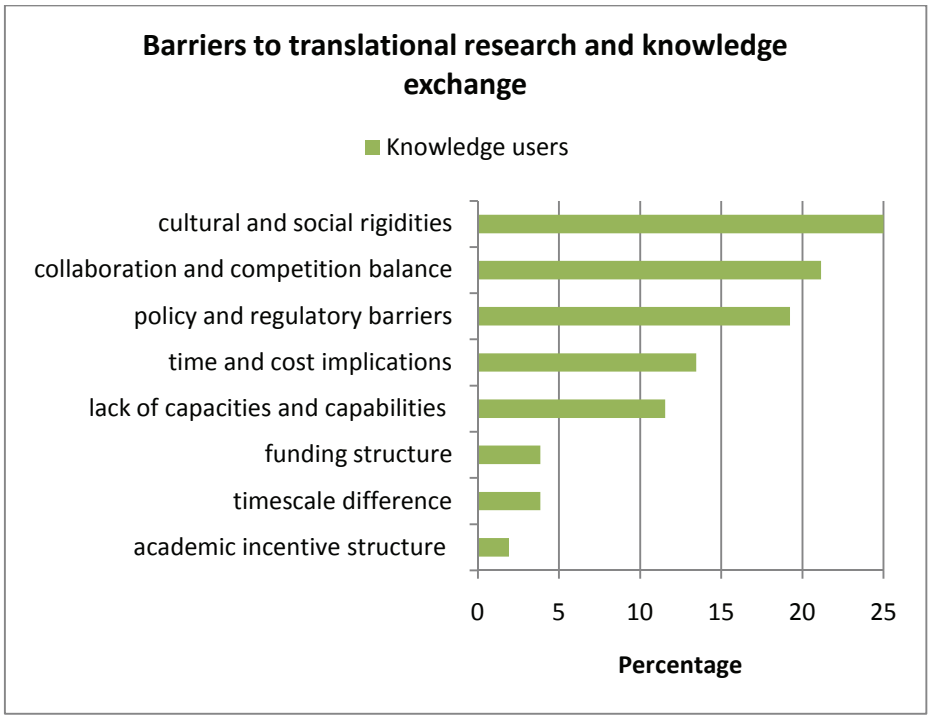


Figure F-10 Knowledge users' barriers to translational research and knowledge exchange

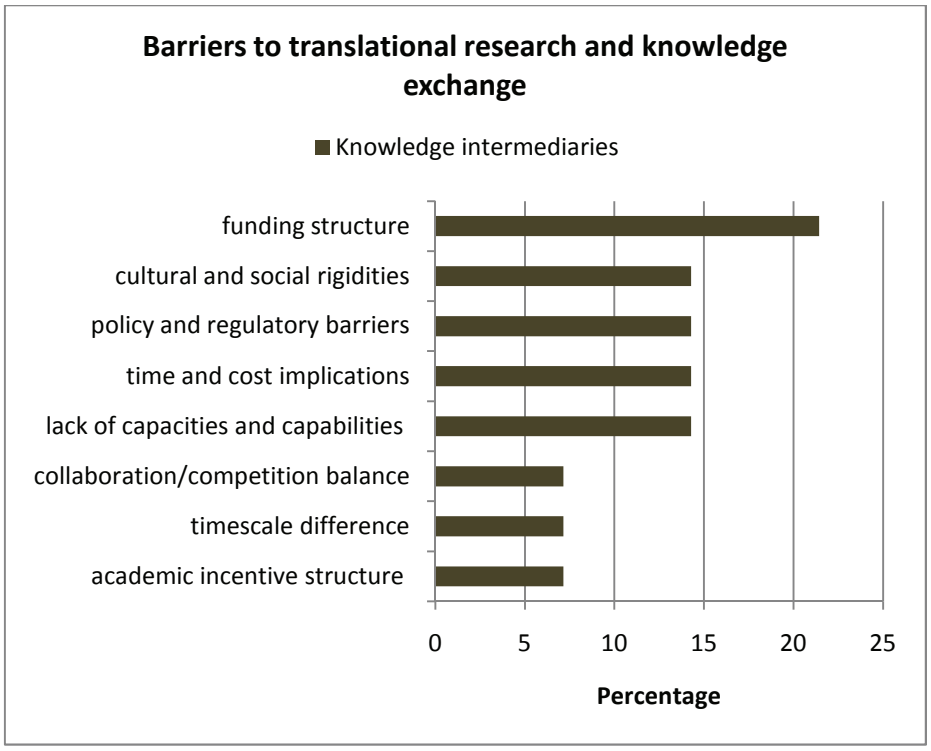


Figure F-11 Knowledge intermediaries' barriers to translational research and knowledge exchange

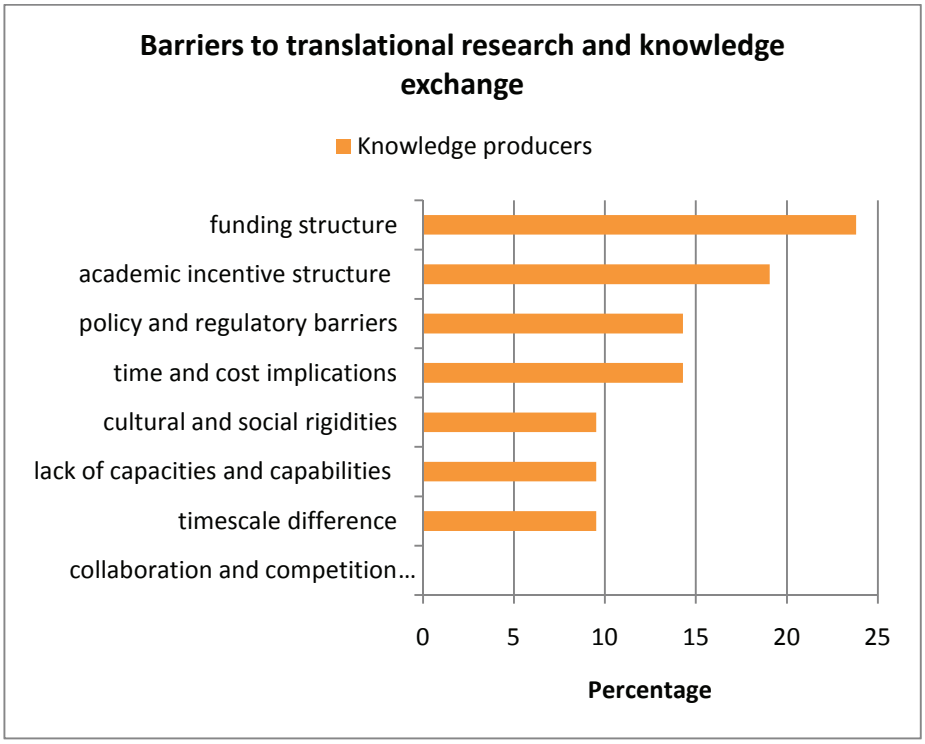


Figure F-12 Knowledge producers' barriers to translational research and knowledge exchange

Enablers of translational research and knowledge exchange

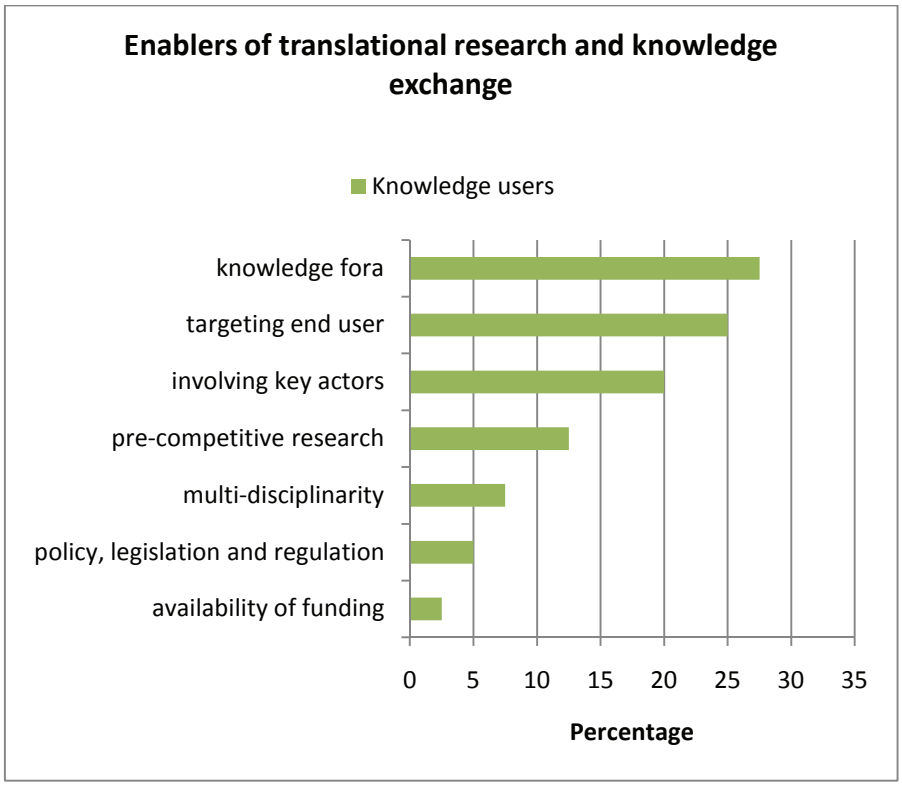


Figure F-13 Knowledge users' enabling factors for translational research and knowledge exchange

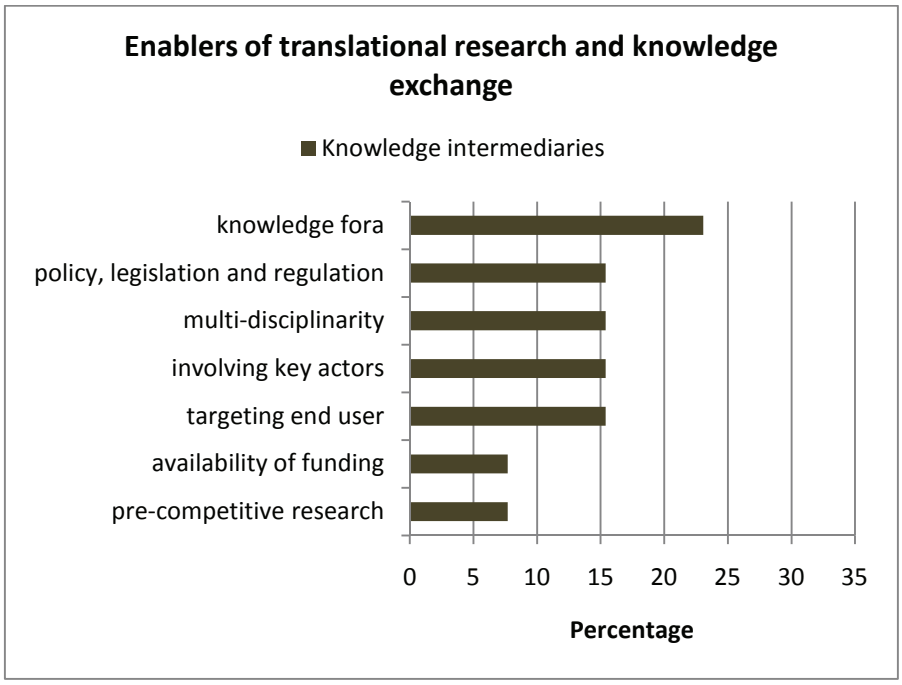


Figure F-14 Knowledge intermediaries' enabling factors for translational research and knowledge exchange

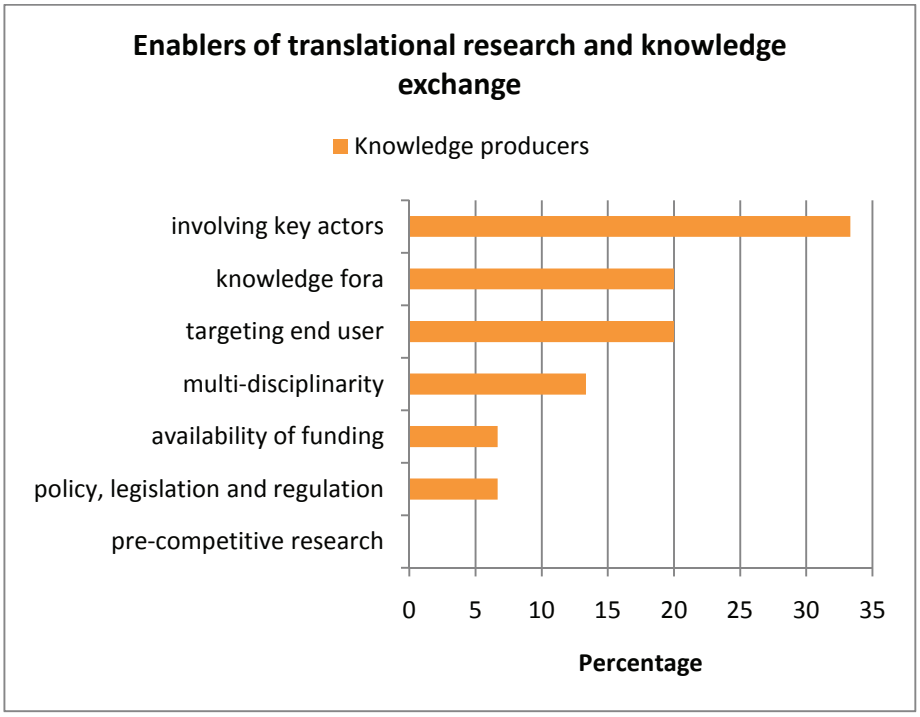


Figure F-15 Knowledge producers' enabling factors for translational research and knowledge exchange

Scope for improvement in translational research and knowledge exchange

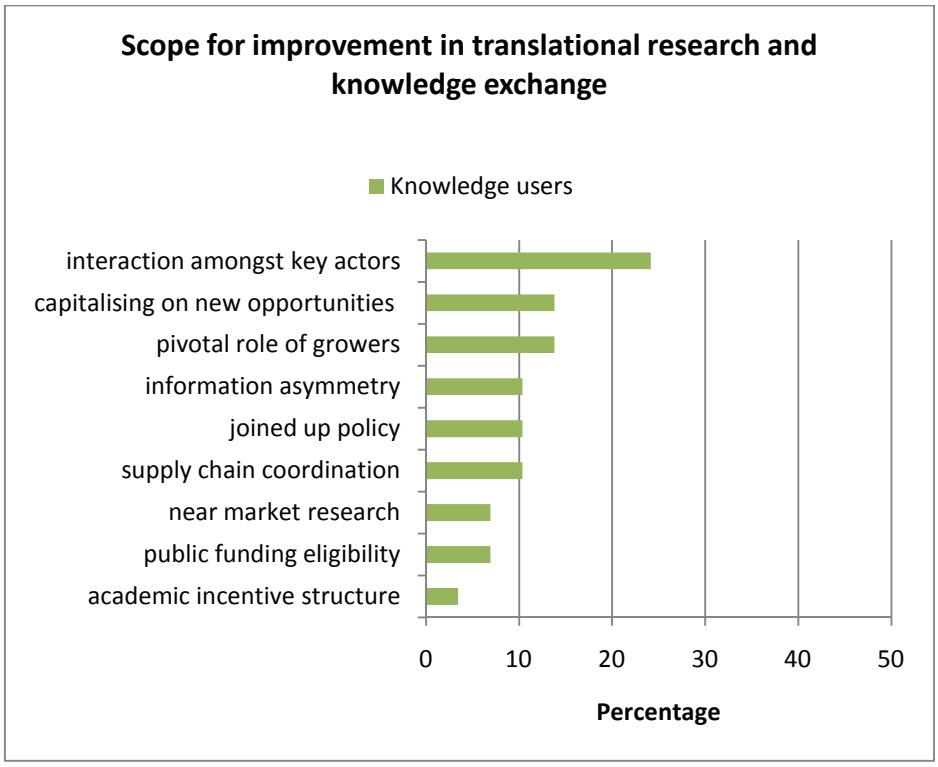


Figure F-16 Figure Knowledge users –areas for improvement

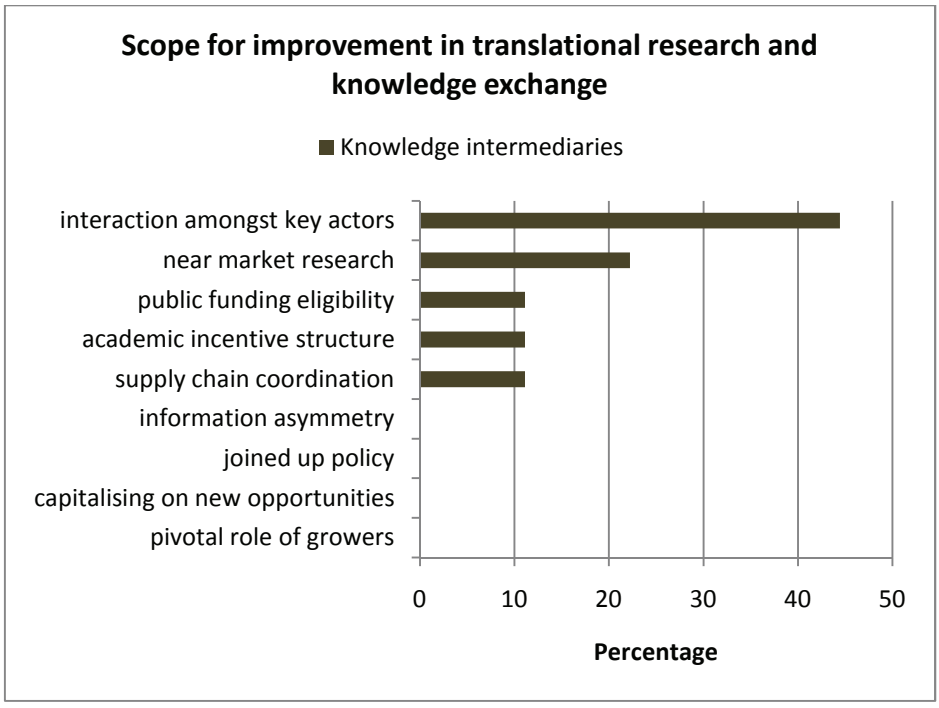


Figure F-17 Knowledge intermediaries –areas for improvement

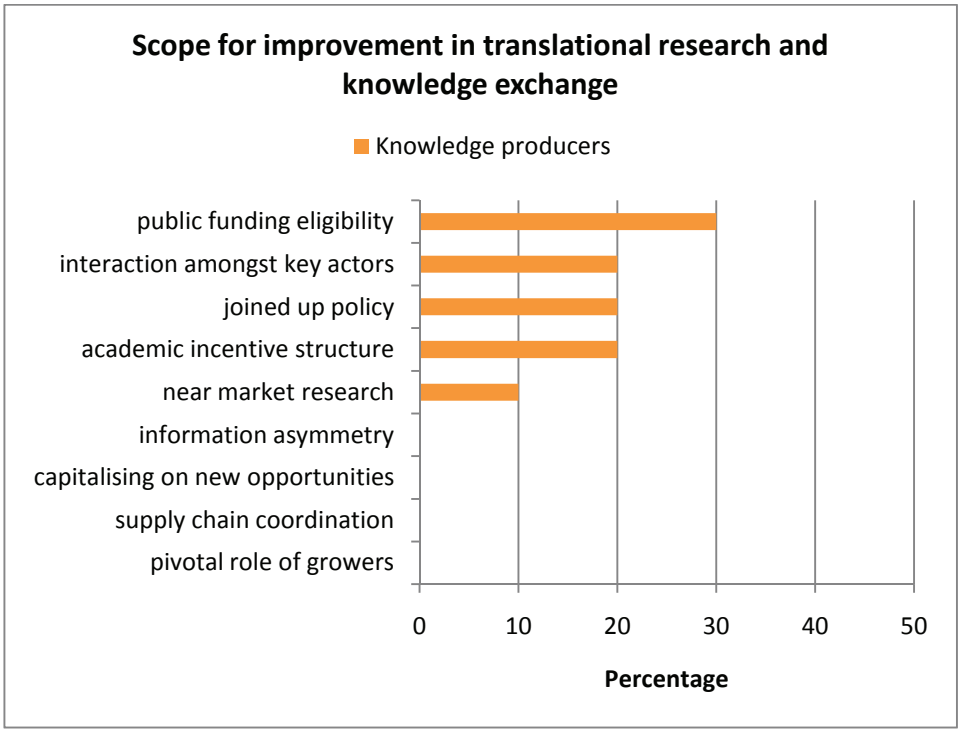


Figure F-18 Knowledge producers –areas for improvement

Appendix G: List of actors and activities used in the actor-activities and actor-actor matrices

Table G-1 List of actors used to develop matrices in chapter 3

PUBLIC SECTOR
Defra (Fera)
BIS - TSB (Technology Strategy Board) (TSB - Sustainable Agriculture and Food Innovation Platform)
Dfid
DH
Devolved Administrations (Scottish Government (RERAD), WAG (Rural Affairs Department), NI (DARD))
FSA (food standards agency)
Research Councils (BBSRC, NERC, ESRC, MRC, EPSRC)
Institute of Food Research
Institute of Biological, Environmental Rural Sciences
John Innes Centre
Rothamsted Research
Scottish Crop Research Institute
Universities
Agricultural colleges (Royal Agricultural College, Royal Agricultural College, Scottish Agricultural College)
Statutory Levy body (AHDB) (HGCA)
PRIVATE SECTOR
Growers (Co-op farms, Grower #22, Grower #23, Sheepdrove Organic Farm, Courtyard Farm Ltd, East Hayden Farm, Rushall Farms)
Millers (ADM Milling, Heygates Ltd, Heygates ltd (interview), Rank Hovis, FWP Matthew Ltd, Allied Mills, Wrights, Letheringsett Watermill, Shipton Mill)
Food and drink producers (Warburtons, Premier Foods, Allied Bakeries, Burton's Foods ltd, Finsbury Food Group PLC, Jordans and Ryvita Comany ltd, Nestle UK ltd, Northern foods Grocery Group , United Biscuits, Weetabix, Tetra Pack, Alara Wholefoods Ltd, Rathbones Bakeries Ltd, Bread Matters Ltd, North Elmhan Bakery, Doves Farm Food, Crisp Malting group**,** Masterfoods, Scottish Courage Ltd, Beverages Systems, Kanes Foods Ltd)

Feed compounders (animal feed) (Heygates animal feeds, Thompson, AB Vista - subsidiary of AB Agri (interview)**,** W&H Marriage and Sons, Biotal Ltd
Biofuel (Ensus, Vivergo, Vireol, British Sugar, Biocaldol Ltd (Bioconversions Technologies Ltd), AB agri – Frontier, BP Biofuels UK Ltd, Green Biologics, TMO Renewables)
Seed companies (KWS, Limagrain UK , SW Seeds Ltd, RAGT, Syngenta, Elsoms, Saaten Union, Advanta Seeds UK Ltd, Nickerson (UK) Ltd)
Sprays (agri-chemicals) (BASF, Syngenta Crop Protection UK ltd, Exosect Ltd, BCP Certis, Yara (UK) Ltd, Field Science Ltd, Croda Enterprises Ltd, Isagro)
Equipment manufacturers/suppliers (Hypro EU ltd, Carrs Agricultrual Ltd, Claydon Yieldometer Ltd, Ecodek Vannplastic Ltd, Proman Coatings Ltd, The Parkes Group, Tubex Ltd**,** Dixon Brothers**,** Biopac UK Ltd**,** Bruker Optics Ltd**,** Knight Farm Machinery Ltd**,** Patchwork Technology Ltd**,** AET Gwent Group, Uniscan Burkard, DMCii, Ozone Systems Ltd, Air Products PLC, Multivac UK Ltd
Plant breeders (DLF Trifolium ltd, Germinal Holdings ltd (BSH), KWS UK ltd, Senova, Limagrain, LS Plant Breeding, Monsanto (UK) ltd, Syngenta Seeds UK ltd, RAGT (no specific activity mention in interview), Masstock Arable ltd, Nickerson - Advanta Ltd, CPB Twyford Ltd, Sylvan Spawn Ltd, Lochow-Petkus GmbH, Bayer CropScience, Advanta UK Ltd)
Merchants (intermediaries between growers and food processing 1) (Frontier Agriculture ltd, Openfields, Glencore, Gleadells, Fengrain, Niedera, CamGrain, Norton Organic Grain Ltd)
Food and drink retailers (Sainsbury's supermarkets ltd., Tesco, M&S, ASDA)
Consultancies and private research (ADAS UK ltd, Campden BRI, Biogemma UK Ltd, Velcourt, Prime Agriculture, Connaught plc, ABP Marine Environmental Research Ltd, Biopharma Technology Ltd**,** Hill Court Farm Research, AJP Wilkinson)
Co-operatives (NetworkGrain UK, Openfield, Organic Arable (Marketing Group), Grain Farmers PLC)
Trade associations (National Association of British and Irish Millers (NABIM), Federation of Bakers, Association of Cereal Food Manufacturers, Biscuit, Cake, Chocolate and Confectionery Alliance, The Maltsers Association of Great Britain, British Starch Industry Association, Food and Drink association (industry level), Consumer association, Scottish Organic Producer Association)
Inspectorate/control body (Organic Farmers and Growers Ltd, Organic Food Federation)
THIRD SECTOR
Charities and Foundations, Not for profit organisations (NIAB TAG - National Institute of Agricultural Botany, Gatsby Charitable Foundation - The Sainsbury Laboratory (TSL), Organic Research Centre (Elm Farm) - a registered charity formally known as the Progressive Farming Trust Ltd, Soil Association, LEAF (Linking Environment And Farming), CABI, Incrops
INTERNATIONAL/REGIONAL BODIES
EU
OECD
FAO
CIMMYT - International Maize and Wheat Improvement Centre
International associations
World Business Council for Sustainable Development
International charities/orgs.

Table G-2 List of upstream activities used to develop matrices in chapter 3

Upstream knowledge activities
crop science (crop production, plant breeding/genetics, seed science, crop protection, plant science (plant physiology), soil science)
Food science and food safety
Organic agriculture
Alternative crop use (biofuel, recyclable packing etc)
Resource efficiency/ climate change
Machinery and equipment engineering

Table G-3 List of downstream activities used to develop matrices in chapter 3

Downstream knowledge activities
Farm inputs/implements (crop protection (pathology/disease control), seeds, genetics, breeding, soil, fertiliser, herbicides, pesticides, machinery & equipment (in the broad sense including precision farming equipment, storage)
On-farm production (farming, farm consultancy/management practices, service provision)
Alternative crop use (biofuel, recyclable packing etc)
Resource efficiency/climate change/alternative crop use (e.g. Recyclable packaging)
Food science/food safety
Food processing 1 (Manufacture) (transformation of raw materials (flour, animal feed, biofuel))
Food processing 2 (Manufacture) food and drink manufacturing (Product improvement, Process improvement)
Distribution (retailing and catering (supermarkets, independent retailers, caterers))

Appendix H: Organisation of production and marketing activities in agri-food

Figure H 1 presents the different stages that are required to bring an agricultural product through the production process to the final delivery to consumers. A supply chain maps out how products are assembled from raw materials or early research to final products.

Wheat is indirectly represented in this figure; wheat is produced by arable farms. The arrows represent a flow of products from on actor to another.

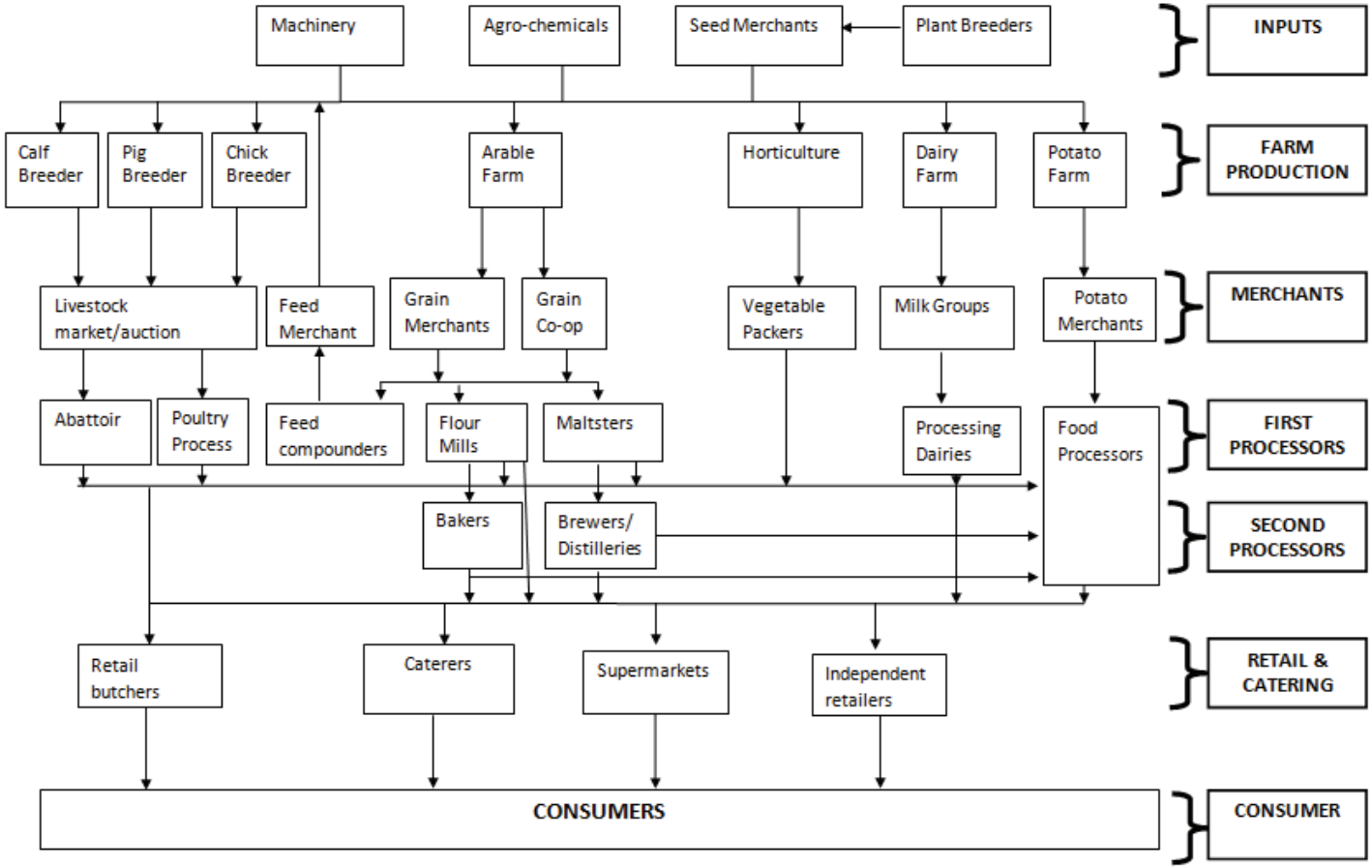
A value chain goes a step beyond a supply chain; it helps to understand how different factors facilitate or constrain improvement in products and processes. The generic conceptual framework presented in Figure 2-1 considers the factors influencing translational research and knowledge exchange in agricultural, which include:

Market structure related factors:

- Actor and activity-related factors such as degree of concentration of actors in each segment of the value chain, extent of segmentation of the value chain, and technologies used along the value chain
- Product and price-related related factors such maturity of the product, number of end use, and price-forming mechanism
- Information-related factors including quality of flow of information across actors

Knowledge-related factors:

- Actor and activity-related factors such as number and dispersion of actors, nature of fields and extent of research
- Governance related factors such as intellectual property rights
- Factor related to funding of knowledge such as source of funding, dispersion of sources



Source: HGCA

Figure H-1 Agri-food supply chain in the UK