# The Impact of Knowledge Transfer Activities on Farm Level Outcomes

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## Statement of Original Authorship

"I hereby certify that the work submitted is my own work, was completed while registered a candidate for the degree stated on the Title page and I have not obtained a degree elsewhere on the basis of the research presented in this submitted work".

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**Abstract**

Agricultural knowledge transfer (KT) activities are services that aim to improve farm level performance by building the capabilities of clients through improved problem solving, decision making and farm management skills. This occurs as a result of an interaction that fosters farmer learning to implement emerging technologies and management practices from research.

Many studies show that interaction with KT services impacts farmer's profitability levels, but most are subject to scrutiny given the multiplicity of methodological options across a range of disparate outcomes. A central challenge of impact evaluations is the level of statistical endogeneity inherent in the findings given biases caused by self-selection, omitted variables and measurement error. Failure to combat these forms of biases can lead to false inferences on the level of impact achieved. Furthermore, much of existing analysis lacks a depth of understanding on the key underpinning processes that drive impact, as many focus on mono-method analysis where representativeness is traded off against depth. This multi-methods research attempts to redress these research gaps by firstly quantifying *what* the level of impact from KT was for participating farmers followed by explaining the process of *how* this impact was achieved at farm level.

Firstly, the impact on farm level income is quantified through an instrumental variable (IV) regression estimation to combat endogeneity concerns. Specifically, the impact of KT participation is estimated on farm income which incorporates all KT activities across all farm systems utilising Teagasc National Farm Survey (NFS) panel data to focus on public KT clients. IV relies on the premise of identifying suitable instruments that affect the decision to participate in KT programmes (relevant) but do not directly affect farm income (valid) in this context. Distance to the local advisory office and the introduction of a policy change which decoupled subsidies from production were chosen as valid instruments. The results indicate a positive impact of 35 per cent for KT participation on farm income over the period 2000-2013 in Ireland, and imply that previous research underestimated the benefits of participation.

The next phase refined the measure of impact to focus on profitability by excluding subsidy related payments which are a significant income support mechanism. This approach also focused on a period during the economic recession when resources to deliver KT services diminished with significant office closures and staff reductions.

Focusing on the Irish case, administrative data is merged with farm level financial performance data from the NFS to test the impact of KT through Random Effects (RE) estimation. The results showed that annual KT contract holders gained a 12.3 per cent benefit to their market gross margin per hectare, but there was a negative effect of 0.2 per cent for each additional client assigned to the adviser which averaged at 9.6 per cent per adviser overall over the period 2008-2014. This implies that the recruitment of additional advisers would positively impact on clients' margins further.

The quantitative analyses provide evidence on the positive impact of KT participation, but does not explain the underpinning factors that drove this impact. The qualitative analysis addresses this gap by providing insight through a series of semi structured interviews with key personnel on both the adviser and client side that were thematically analysed. By focusing on the capacity and methods to deliver the service, the subsequent effectiveness of the interaction, and the learning and implementation by the farmer to explain the key factors that lead to impact. The results showed that the motivation of the farmer to participate, learn and implement new knowledge are the key drivers of impact from KT and that this depends on the level of trust and credibility in the organisation, their relationship with the adviser and the types of activities and specific content on offer.

The multi-methods approach adopted in this study ensured a robust analysis that could be harnessed further for evaluations more generally. This study applied both quantitative and qualitative methodologies in order to achieve a more accurate and more valid analysis, through complementary insights to deepen the overall understanding of KT impact. The findings showed that there was a positive impact for KT participation, although the level of this impact was confounded by the need to efficiently deploy resources as well as the key roles of both farmers and advisers in a process underpinned by trust. These insights provide valuable evidence that can support policy making on efficient resource deployment for public KT providers to achieve future targets as set by government.

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Firstly, I would like to offer my sincere thanks to my four supervisors for their constant support, expertise and guidance throughout this process. Each supervisor made a significant contribution and I can honestly say that having all four was a blessing for this study as each offered a unique set of expertise that I could harness to develop the study. Thank you to Kevin for offering me this opportunity and always being available when I needed advice. Thank you to Maura for her constant support and always keeping me focused on the bigger picture. Thank you to Cathal for his expertise on the quantitative side and always putting me forward to take advantage of all opportunities. Thank you to Rachel for her expertise on the qualitative side and general writing to ensure that the final manuscript was of the highest standard.

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## Publications and Presentations

**Publications related to this work:**

Cawley, A., O'Donoghue, C., Heanue, K., Hilliard, R. and M. Sheehan (2018) "The Impact of Extension Services on Farm Level Income: An Instrumental Variable Approach." *Applied Economic Perspectives and Policy* 40:1-28.

Cawley, A., O'Donoghue, C., Heanue, K., Hilliard, R. and M. Sheehan (forthcoming) "The Impact of Knowledge Transfer on Farm Level Margins during the Economic Recession: A Quantitative Study." *The Journal of Agricultural Education and Extension*

**Oral Presentations:**

Irish Society of New Economists 11th Annual Conference, September 2014, Galway, Ireland.

Agricultural Economics Society Annual Conference, April 2015, Warwick, UK.

The European Association of Agricultural Economists 150th Seminar, October 2015, Edinburgh, UK.

Regional Science Association, British and Irish Section 45th Annual Conference, August 2016, Newquay, UK.

European Seminar on Extension and Education 23rd Biannual Conference, July 2017, Chania, Greece.

Teagasc Walsh Fellowship Seminar, November 2017, RDS, Dublin, Ireland.

**Poster Presentations:**

Whitaker Research day, April 2017, Galway, Ireland.

## Glossary of Terms

| | |
|---|---|
| AI | Artificial Insemination |
| BETTER | Business Environment and Technology Through Extension and Research |
| CAP | Common Agricultural Policy |
| DAFM | Department of Agriculture, Food and the Marine |
| EBI | Economic Breeding Index |
| EU | European Union |
| FADN | Farm Accountancy Data Network |
| FFI | Farm Family Income |
| GDP | Gross Domestic Product |
| ICT | Information and Communication Technology |
| IV | Instrumental Variable |
| KM | Knowledge Management |
| KT | Knowledge Transfer |
| MGM | Market Gross Margin |
| NFS | National Farm Survey |
| OLS | Ordinary Least Squares |
| RE | Random Effects |
| 2SLS | Two Stage Least Squares |

# Chapter 1 - Introduction

## Introduction

The agricultural sector faces many economic challenges ranging from increasing the level of productivity to feed a growing global population whilst reducing negative environmental externalities associated with food production whilst providing a viable enterprise for producers. In order to resolve these challenges, it is important that farmers are equipped with adequate knowledge to deliver a positive impact on this multitude of objectives. Within this context the demand for credible information and knowledge has grown as producers aim to achieve these objectives while simultaneously navigating through complex policies when making production and management decisions (Garforth et al. 2003). Agricultural knowledge transfer (KT) services are important in this regard as they act as policy levers to assist governments in influencing farmer behaviour through a mixture of incentives and regulations to achieve targets. This study draws on the definition of KT provided by Läpple et al. (2013) that the purpose of KT is to improve farm performance by connecting research with farm practices through transferring specialist knowledge and adopting new technologies to achieve set objectives. This is appropriate as this study prioritises interactions with the public KT service provider in Ireland, Teagasc, to evaluate their impact related to economic performance indicators for technical based advice on management practices for participants. Specifically, the factors that motivate farmers to participate in KT and to implement the newly acquired knowledge at farm level, and the resulting economic impact of this decision is the central focus of this study.

KT is often delivered through agricultural extension bodies that can enhance the capabilities and capacities of clients, by transferring knowledge and skills to improve problem solving, decision making and management abilities (Tamini 2011; Vanclay and Leach 2011). Lio and Liu (2008) argued that agricultural productivity improvements were at least partially dependent on effective extension services, combined with various other factors such as sound macroeconomic policies, appropriate governance, infrastructure, education, and the provision of public goods and services. This dissertation aims to quantify the impact of these services and explain the process of how impact is achieved at farm level.

Garforth et al. (2003) highlighted that most developed countries have established a form of public extension service for farmers funded largely from general taxation and delivered by public organisations. Governments actively promote extension services as a means of knowledge diffusion, technology adoption and to develop innovative solutions to emerging challenges (Läpple and Hennessy 2015). This form of public extension service has since been supplemented by the private sector with the overall aim of developing the individual and collective performance of farmers. Recent reforms of the Common Agricultural Policy (CAP) within the European Union (EU) have raised additional challenges concomitant with national strategies such as Food Wise 2025 in Ireland, where ambitious targets for each sector are set. Indeed, in 2009 the EU introduced a regulation (73/2009) on farm extension services that ensures this form of policy instrument is available in each member state without specifying how it is delivered (Prager et al. 2016).

The provision of an efficient public KT service is confronted with multiple challenges from their dependence on the broader policy environment which also includes fiscal (Anderson 2008), which has led to a renewed emphasis on 'value for money' from the service to recognise the benefit to investment (Massingham and Massingham 2014). KT clients must also experience value for money from participation given their income challenges exacerbated by economic volatility and a strong reliance on subsidy support payments (O'Donoghue and Hennessy 2015). Accordingly, a robust evaluation of existing KT services is a pertinent exercise to evaluate the level of impact achieved and to understand the drivers of impact in order to continually develop and provide an efficient service (Kidd et al. 2000). This is the primary focus of this research.

Many studies have shown that interaction with extension services influences farmers' technology adoption decisions, productivity and profitability levels (see Hennessy and Heanue, 2012; Lio and Liu, 2008, O'Donnell, 2010, Rahman and Salim, 2013; Tamini, 2011; Wang 2014). These studies vary significantly in their methodological approach given the diverse options for conducting evaluations and a disparate range of outcome measures (Hagger-Johnson et al. 2013; Läpple and Hennessy 2015). Many studies are conducted as mono-method analyses with quantitative studies focusing on measuring the level of impact, whereas qualitative studies typically investigate the underlying factors that influence KT services. Multi-methods analysis utilises both formats to quantify the level of impact and explain the process of KT related impact. This ensures a superior methodological approach that identifies *what* the level of impact was, as well as *how* that impact was achieved. This is the key focus of this research.

**Context**

Agricultural extension programmes are operated by multifunctional organisations that provide advisory services to the farming sector. Extension programmes could be viewed as risk management devices from policy makers to mitigate issues in the rural economy, or as drivers of growth at farm level to ensure best practices are followed systematically. Läpple et al. (2013) summarised the definition and purpose of extension services as a programme to improve farm performance and introduce new technologies to connect emerging research to on-farm practices. Thus extension programmes assist farmers to overcome barriers to achieving set goals due to a lack of knowledge, motivation, resources, insight and power or a combination of these (Van den Ban and Hawkins 1988). Extension programmes aim to assist farmers on issues such as productivity, profitability, food safety and the environment among others (Boyle 2008).

This research focuses on the Irish case where the Irish agriculture and food sector accounts for approximately 5.7 per cent of Irish Gross Domestic Product (GDP) as well as employing 167,500 people which is approximately 10 per cent of total employment (Teagasc 2017). Recent statistics from the Department of Agriculture, Food and the Marine, outline that Irish agriculture contributes 10.5 per cent of total exports, accounts for 7 per cent of gross value added at factor cost, and employs 7.7 per cent of the labour force (DAFM 2015). When employment in inputs, processing, and marketing are included the employment figure rises to 10 per cent (Teagasc 2015). Thus, the importance of the agricultural sector to the Irish economy is considerable, and has associated implications for rural development in the country. Accordingly, the on-going success of the sector will be aided by an efficient, targeted, effective extension service.

The extension service in Irish agriculture consists of both public and private consultants, with clients split relatively evenly among both types. Prager et al. (2016) estimated approximately 250 private advisers (mainly represented by the Agricultural Consultants Association) were in operation alongside 250 Teagasc advisers. Teagasc is the main body for the public delivery of agricultural research, advice and training since 1988. It is a unique organisation that combines research, extension services and education within the same organisation (Prager et al. 2016). The operating budget for Teagasc is approximately €160 million per annum with 30 per cent of the total allocated to KT related services (Teagasc 2016). The KT services include a variety of activities to stimulate learning and influence farmer behaviour through targeted interactions involving both individual and

group based environments. Clients pay a monetary fee for service that varies depending on the type of contract and intensity of the programme. Teagasc serves approximately 40,000 farmers in Ireland with 52 local KT offices and approximately 250 advisers. Farmers can avail of technical based advice on production, financial advice, assistance with claiming policy schemes, and education courses with Teagasc.

The Teagasc KT service focusses on four programme areas, namely 1) Business and Technology, 2) Environmental and Good Farm Practice, 3) Rural Development and 4) Adult training and Life Long Learning, and these are run concomitantly with host monitor farms for demonstration and client interaction. These programmes focus on farm level outcomes such as profitability, sustainability, biodiversity, diversification, innovation and technology adoption. These diverse outcomes reflect the complex objectives for extension providers, whilst also highlighting the challenge for conducting evaluations of impact. This research focuses on the area of Business and Technology to evaluate the impact of KT services on farm level outcomes related to productivity and profitability. Within this programme, Teagasc offer a range of activities that includes one-to-one consultations with the adviser, discussion group participation, mass events such as open days or farm walks as well as a structured education programme. A full overview of the KT services is provided in Appendix A.

The broad range of services ensures that farmers can receive advice on both technical and financial advice among others. However, for the purpose of this study, the focus is on two technical based management practices (Grassland and Breeding) and one financial (use of the E-profit monitor), as well as evaluating the activities most suited to delivering this content and achieving an impact. These specific practices are important in driving impact on farm level and thus, have been prioritised by Teagasc, and each is defined and explained in detail in Chapter 3 and Chapter 6.

**Contribution, Objectives and Research Questions**

The purpose of this study is to evaluate the impact of KT services on farm level performance. Performance is measured in terms of profitability primarily to ensure a common outcome measure across all farm enterprise types. The key assumption is that farmers participate in KT services to improve their financial performance, as opposed to alternative functions such as environmental mitigation or social objectives. This study aims to quantify the level of impact and explain how that impact was achieved. This

ensures a theoretical and empirical contribution by addressing the dual research questions of *what* was the level of impact and *how* that impact was delivered through a multi-methods analysis. The quantitative analysis focuses on estimating the level of impact and the qualitative focuses on explaining the process that achieved the impact. This approach provides a robust evaluation of public KT services that contributes to the literature in a number of ways.

Firstly, this analysis quantifies the impact of KT participation on farm level income over a 14 year period using Teagasc National Farm Survey (NFS) panel data. The NFS is a nationally representative data set collected to fulfil the requirements of the Farm Accountancy Data Network (FADN), a prerequisite for all EU Member States. This was done as a means to extend existing research, by providing an unbiased causal effect of KT participation on farm level income. Farm income was chosen as the dependent variable on which impact is measured to include all levels of KT participation across all farming types by focusing on a common outcome. Farm income is defined as the total returns from the farm enterprise, but also includes subsidy payments related to schemes which are a form of income support provided through public policies. Assistance with these schemes is an important function of KT providers and therefore was included in this analysis.

To ensure the analysis is robust it is important to recognise the challenge of estimating impact due to multiple confounding factors that affect this impact which causes a bias in the estimation. These factors include self-selection biases related to the motivation to participate or not, omitted variable biases such as farmer innate ability and errors in measuring the variable. These biases relate to inherent issue of statistical endogeneity where other factors influence the result, which can lead to false inferences on impact (Abdallah et al. 2015; Akobundu et al. 2004). This obstacle is overcome by adopting an instrumental variable (IV) estimation approach which purges the endogeneity and therefore provides a superior estimate of impact. The empirical contribution estimates the average impact of KT participation on farm income over the period 2000-2013. This enriches the subsequent analyses by identifying a general measure of financial impact for KT participation, before refining this measure to focus on profitability.

Thus the first research objective is to provide an aggregated evaluation of KT services on farm level income by controlling for endogeneity through IV regression. Accordingly, the first research question is:

1. What was the impact of KT participation on farm-level income?

The second objective of this research builds on the first contribution by refining the measure of impact to focus on profitability. Specifically the impact of KT participation on farm level margins is assessed for annual contract holders. Farm level margins are calculated by removing subsidies from the outcome measure whereas annual contract holders prioritise farmers who participate for technical advice to improve their performance as opposed to scheme assistance only. This provides a superior measure of KT impact related to technical based advice implemented on farm. In addition, the capacity for a KT provider to deliver an impactful service is dependent on the efficient deployment of resources (Kidd et al. 2000). This analysis focuses on a period of significant organisational change related to a consolidation of resources due to the economic crisis from 2008 to 2014. This consolidation process presented multiple challenges for public KT in Ireland in terms of resource deployment with significant office closures and staff reductions. This reduced the capacity to deliver the KT service and increased the ratio of clients per adviser as client numbers remained relatively stable during this period. This analysis merges administrative data on resources with the Teagasc NFS to estimate the impact of KT participation on farm level profitability. The increased ratio of clients per adviser is included as a key variable to represent the consolidation of resources and the impact is estimated through a random effects (RE) model over the period 2008-2014. This will provide a valuable contribution to future policy discussions on the deployment of resources for public KT providers, by providing evidence on what level of value can be attributed to delivering the service, as well as the spatial considerations and the importance of adviser client ratios. Thus the second question is as follows:

2. What is the impact of KT annual contracts on farm level margins during the economic recession?

The quantitative analyses is necessary and informative, but the substance and depth of understanding required to examine the process of KT requires formal qualitative inquiry (Hodge and Midmore 2008). The quantitative analyses provide a measure of impact for

KT service participation on farm level financial performance which identifies the value of the service, but falls short of an in depth understanding of the key factors that drive impact. In other words, the quantitative results reveal *what* the level of impact was but do not explain *how* that impact was achieved. The qualitative phase of the research aims to bridge this gap by gaining an improved understanding of the KT process and the underpinning factors that facilitate or restrict impact. The insights of key informants within the KT process ensure that the quantitative results are inferred accurately by providing additional data surrounding those relationships (Prager et al. 2017). Semi-structured interviews are conducted with both advisers and farmers through a purposive sampling approach that focuses on farmers that are most likely to receive the largest impact from KT participation and their respective advisers. Key themes derived from the theoretical discussion informed this analysis including the motivation of farmers to participate and implement newly learned knowledge, the dynamic roles of both advisers and farmers and the importance of trust to encompass and enhance impact. These insights deepen our understanding of the key drivers within the KT process that lead to farmers implementing a change on farm that improves their performance. Specifically, the third research question is as follows:

3. How is KT impact achieved at farm level?

To comprehensively address these research questions a sound methodology is required. A brief overview of the methodology is provided in the following section.

**Overview of Methodology**

There are a number of challenges associated with assessing the impact of KT participation on farm level performance due to the multiple methodological options, disparate outcomes and the complexities and accuracy of the variables being studied (Läpple and Hennessy 2015). For example, the phase of the farmers' career, policy and market influences, bidirectional information flows and statistical endogeneity caused by confounding factors (Birkhaeuser et al. 1991). Controlling for these factors is the key challenge in evaluating impact in order to estimate accurate results (Argote and Ingram 2000). Coupled with this challenge is to determine the specific aspect of KT to focus on given the pluralistic functions of KT services, the diverse formats of interactions that cover a broad range of outcomes. This challenge is overcome by utilising a multi-methods approach. This approach provides quantitative evidence on impact as well as deepening

our understanding of the mechanisms that lead to this impact through qualitative investigation (Faure et al. 2012). This approach is appropriate to quantify the level of impact achieved on farms through KT participation as well as extrapolating the underpinning factors that drive this impact.

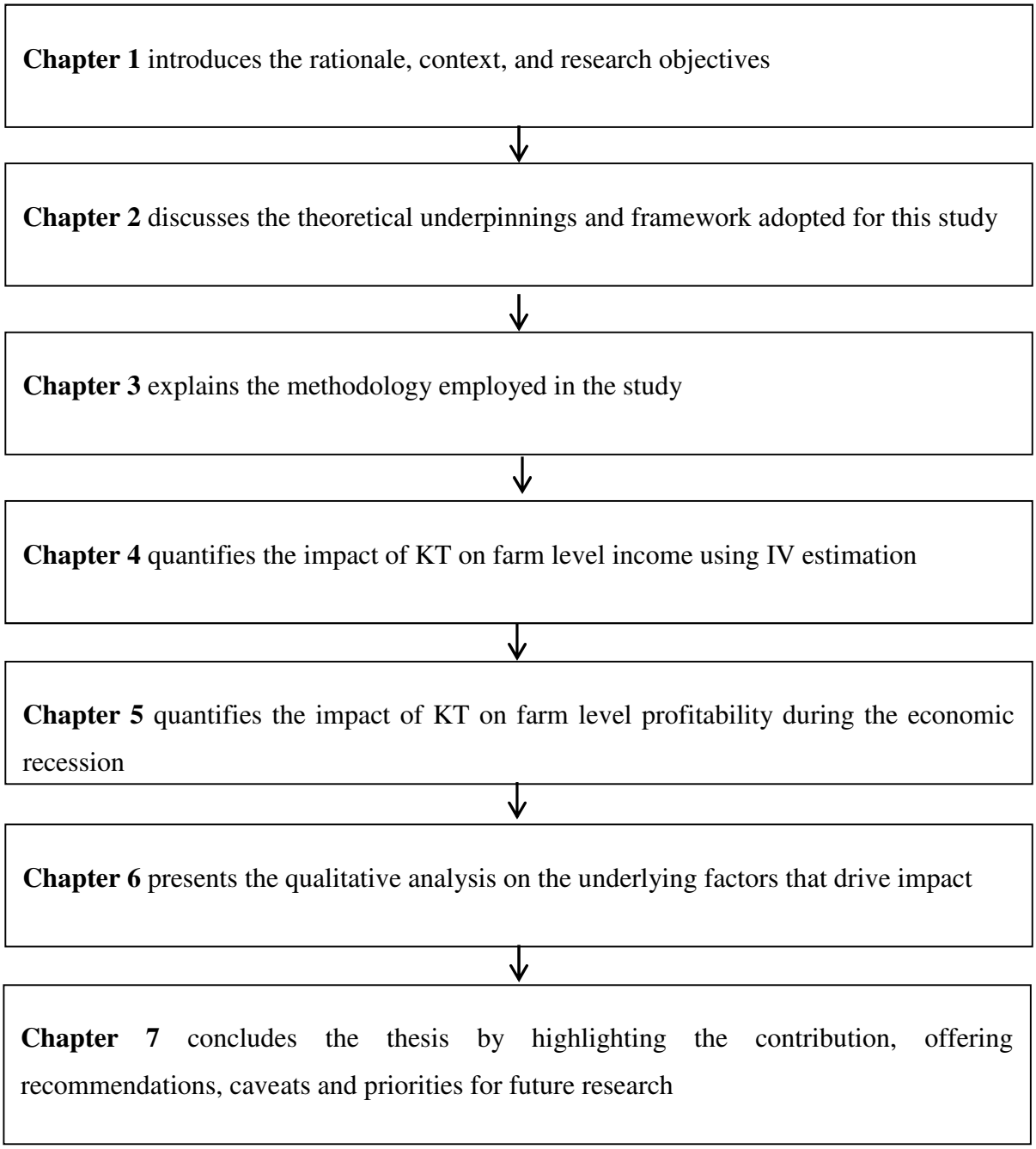
The analysis was conducted on a phased basis, with the initial quantitative analyses estimating the level of impact achieved through KT participation from a nationally representative panel data set over the period 2000-2014. Econometric techniques, namely instrumental variable and random effects estimation are employed to provide a robust estimation that controls for confounding factors. The qualitative analysis investigates the underlying factors that affect impact following a pathway adapted from the Birner et al. (2009) framework for KT evaluations. The adaptation of this model hones the focus of the research and measures impact through an identified pathway divided into key phases including the preparation of knowledge for KT, the KT exchange itself, and the subsequent learning and implementation of newly acquired knowledge. Semi-structured interviews are conducted with advisers and farmers to examine the factors they perceived as most relevant for achieving impact.

This comprehensive strategy provides an in-depth analysis that contributes to existing literature theoretically and empirically. The methodology is described in depth in Chapter 3 as well as within each analytical chapter.

**Outline and Structure of Thesis**

The structure of the thesis is set out in Figure 1. The next chapter discusses the theoretical underpinnings of this research which is followed by a more detailed overview of the methodology to further justify the multi-methods approach. This is followed by the quantitative analyses and qualitative work. The results are synthesised and discussed in the final chapter, before conclusions, caveats and recommendations are presented.

**Figure 1 Outline and Structure of Thesis**



# Chapter 2 - Theoretical Background

## Introduction

In order to conduct the analysis, it is important to outline the theoretical context in which this research is situated. To conduct an effective evaluation requires detailed knowledge of the background contexts that shape the likely impact of a specific action on the population of interest (Walker et al. 2009). The contexts relevant to this study refer to the underpinning theories of knowledge and the challenge of its transfer, the provision of public agricultural advisory services and the characteristics of participating farmers. The purpose of this chapter is to establish the theories being studied, and to explain the context that sets the research questions. The transfer of knowledge refers to creating knowledge in one location, and putting it to productive use in other locations (Noorderhaven and Harzing 2009). Agricultural knowledge transfer (KT) refers to the creation and transfer of knowledge through an agricultural extension service where new technologies and practices are communicated to participating farmers for use on their individual farms. However, a more specific understanding of the concept and process involved is necessary to grasp the complexities in achieving impact.

The chapter is structured as follows: first, the theory surrounding the value of knowledge creation is presented followed by a discussion on the challenge of transferring that knowledge, the intricate role of providers to carry out the KT service and for receivers to learn and implement newly acquired knowledge. Next the organisational framework adapted for this study is described in depth to explain the pathway to impact used for the evaluation.

## Theory of Knowledge

Knowledge can be thought of as the acquisition of expertise on a particular subject area gained through experience or education. It has been defined as a resource that is located within an individual or a collective, or embedded in a routine or process, but ultimately results in an increased capacity for decision making and action related to a specific purpose (De Long and Fahey 2000). Knowledge can be transferred explicitly through communication from one unit to another based on a specific practice that improves performance, or implicitly when the recipient absorbs new knowledge perhaps without fully understanding how or why, for example through following a routine (Argote and

Ingram, 2000). This is a central objective of agricultural KT, to enhance client capabilities through improved problem solving skills, decision making and more effective farm management (Vanclay and Leach 2011). The debate on contrasting knowledge, information and data itself has been on-going in the literature, with some authors distinguishing between the concepts (Boisot and Canals 2004) and others noting their interrelationships and perhaps co-dependency (Bruckmeier and Tovey 2008). Within an agricultural context this debate is unresolved and warrants an in-depth discussion for clarity in this study. Each term is described in isolation first before subsequently discussing their linkages.

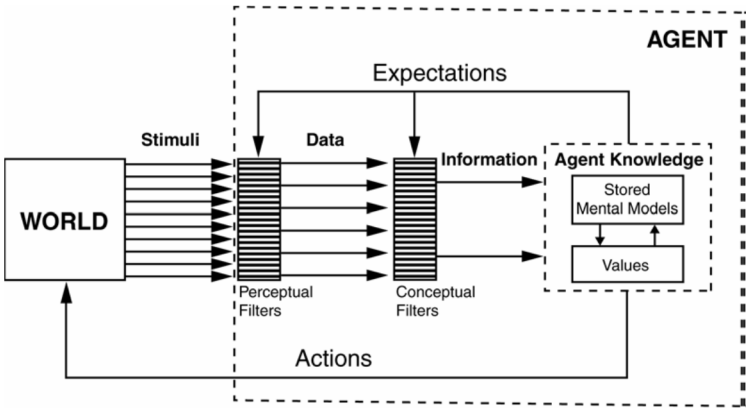
De Long and Fahey (2000) differentiate between the concepts of knowledge, information and data on the basis of data described in a raw format, information labelled as a pattern interpreted from the raw data and knowledge defined as a product of human reflection and experience on that information. Boisot and Canals (2004) distinguish hierarchically between these concepts with knowledge setting the contextual background to interpret information that has been initially derived from data. This implies that information comes from raw data and can be modified into new knowledge. Information can flow down a 'grapevine', but this differs from knowledge flow, where the receipt and application of new skills is performed and therefore knowledge is demonstrated (Aalbers et al. 2013). Information is primarily descriptive whereas knowledge can be thought of as prescriptive or an evaluative summary of a particular task, topic or recommended advice (Bonaccio and Dalal 2006). Within this context farmers seek advice to improve their knowledge which can frame their decisions, refine their preferences and create options to improve their performance (Yaniv and Milyavsky 2007). This interpretation of knowledge implies a deeper level of 'knowing' than either data or information. Bruckmeier and Tovey (2008) argue that preceding knowledge is needed to organise new data and information, but it is knowledge that is needed for interpretation. Similarly, Tuomi (1999) argues contextual knowledge is necessary to interpret and understand information. For example, a researcher may require a certain level of econometric knowledge prior to interpreting a table of regression results, or a farmer may require a level of scientific knowledge to interpret their soil sample results accurately. The conversion of information into knowledge requires effective communication, assimilation, interpretation and implementation skills which are based on the trust of the recipient farmer in the process (Fisher 2013). Nonetheless, the acquisition and application of expert knowledge is a critical component of agricultural performance and rural development and ensuring

access is a key issue for providers, particularly public providers (Kidd et al. 2000; Prager et al. 2016).

*Conceptual Examples*

Boisot and Canals (2004) summarised their idea of knowledge as a base that can be modified with key information extracted from raw data. Their illustration is presented in Figure 2:

**Figure 2 Knowledge Creation**




*Boisot and Canals (2004)*

While this graphic distinguishes between data, information and knowledge, and shows the complex interrelationships within, it is not applicable to all types of sectors (Boisot and Canals 2004). However, it may be applied in an agricultural context if for example data is assumed to represent raw market data, information to represent specialised newsletters that show the market trends and knowledge as the basis for making decisions to improve the farm based on the interpretation of the information. The KT process delivered through the extension service can smooth this process as well as the individual adviser in translating data and information into usable knowledge for farmers. In contrast Sewell et al. (2014) argue that the 'scientist' and 'farmer' collaborate together to interpret new knowledge and mutually share expertise which also assists the knowledge flow process. This typically occurs in a group based participatory KT method such as a discussion group where advisers and farmers collaboratively discuss problems to identify solutions.

Alternatively Daft and Weick (1984) provide a simpler form of this process by focusing on the 'interpretation' of data to create knowledge through learning. They defined

interpretation as the process of translating events, into understandable models that can be assembled into an action. Their approach is illustrated in Figure 3:

**Figure 3 Relationships among Scanning, Interpretation and Learning**


*Daft and Weick (1984)*

These stages are interconnected through a feedback loop where learning can inform data collection and analysis (Daft and Weick, 1984). Knowledge can be absorbed in all stages (Minbaeva et al. 2013), but the action taken is the key stage when evaluating the impact of new knowledge. The action stage is of key interest for this study which is where the farmers decide to implement the knowledge learned through the KT interaction.

*Types of Knowledge*

There are various forms of knowledge defined in the literature that can be divided into explicit or implicit formats which create different challenges for transfer. Explicit knowledge is a codified format that is typically documented into formal rules and processes whereas implicit knowledge or 'tacit' knowledge is what is known by the owner but difficult to explain (De Long and Fahey, 2000). Tacit knowledge is gained through experience, or 'learning by doing' (Ashiem and Coenen 2005), and is typically retained by the individual alone as each experience differs. Human knowledge is based on the level of skill and expertise that combines explicit and implicit knowledge, while social knowledge is based on relationships developed with others, and structured knowledge is based on systems, processes, tools and routines (De Long and Fahey 2000). Common knowledge is knowledge that everyone knows, and that everyone knows that everyone knows it (Samuelson 2004). All these forms of knowledge are relevant in an agricultural context where farmers choose to participate in KT programmes based on their desire to improve their knowledge. For example, Pasquini and Alexander (2005) found that farmers identified their perceived optimal strategy for production based on their inherent tacit knowledge of local conditions as well as their interpretation of explicit knowledge stemming from research.

Ingram and Morris (2007) drew on the previous work of Lundvall and Johnson (1994) to create typologies of knowledge. They described knowledge in the form of 'know-what', 'know-why', 'know-how' and 'know-who' and discussed the complex role of each. In short, they argued that know-what is largely codified knowledge about facts. Know-why is knowledge of principles, technologies and regulations, know-how is the skills to practically apply knowledge (largely based on tacit) and know-who is the ability to network to increase knowledge. Know-what and know-why represent explicit knowledge formats that can be codified and documented. In contrast, know-how is typically learned in an apprenticeship environment where the 'master' bestows their expertise to an 'apprentice' in a top-down linear format (Jensen et al. 2007). This form of knowledge is gained by 'doing, using and interacting' with a particular skill or method (Ingram and Morris 2007). Know-who reflects a strategic knowledge to 'know who knows what' (Samuelson 2004), which can be a top-down format as in an apprenticeship or a more social participatory horizontal knowledge exchange with peers of similar experience (Jensen et al. 2007). These typologies are important in the context of this study as all contribute to KT related impact.

*Knowledge as a Resource*

The work of Stigler (1961) to place an economic value on the search for information was an important development in quantifying the importance of knowledge as a resource and its transfer in industry. His detailed paper developed a cost for buyers and sellers related to information on optimal pricing, the quality of goods and improved production techniques. Stiglitz (2000) credited this work as recognition of the imperfections, asymmetries and costs surrounding the obtainment of knowledge and the influence individuals and firms possess on the sharing and transfer of that knowledge. He continued that this was fundamentally different to other tradable commodities, citing the importance of specific mechanisms such as trust-based reputations when buyers and sellers interact to exchange information.

Stiglitz (2000) predicted that future research would focus on the absorption of information, the reaction and learning of individuals and the systematic design of firms to create, transmit and use knowledge and information. For example, the utilisation of formal network structures can enhance employee learning through increased interactions supported by trust and a shared understanding of common objectives (Aalbers et al. 2013). This logic can be applied in an agricultural context although the organisational design of

farms is different to firms. For example, the organisational structure of Irish farms is typically a small sole trader type enterprise that does not compare with medium sized enterprises or multinational corporations. Farmers can be conceptualized as reactive dynamic business operators who face physical constraints such as land and climate whilst being influenced by social and policy expectations that motivate their decisions (Morris et al. 2017). KT participation may well result in the acquisition of new knowledge, but the implementation will vary dependent on the farmers' tacit knowledge and motivation which is characteristic of the heterogeneous nature of the sector. Nonetheless, the importance of trust, consistency and regular contact for farmers is important in the KT process (Fisher 2013).

The agricultural sector embodies various forms knowledge as outlined above, but the difficulty of transferring this knowledge is the key challenge. Explicit codified knowledge is less problematic to transfer but implicit or tacit knowledge presents a significant challenge. Tacit knowledge may not be captured through standard verbal reports and an alternative approach is needed to measure its transfer (Argote and Ingram 2000; Coccia 2008). In contrast, it is more likely to transfer tacit knowledge in a networked environment that fosters participatory learning (Galindo 2007), or through an apprenticeship format (Jensen et al. 2007). The impact of this transfer is the focus of this study, and the roles of advisers and farmers within the agricultural KT service are examined to determine their roles in the process. These roles are discussed in depth in subsequent sections, but first it is necessary to discuss agricultural KT in more detail.

**Agricultural Knowledge Transfer**

Agricultural KT services differ than those applied in organisations and firms mainly due to the diverse and fragmented structure of the agricultural sector. These services are delivered through extension providers. There are various definitions for agricultural extension, albeit within broadly accepted parameters, but this variety of concepts can cause confusion (Prager et al. 2016). Van den Ban and Hawkins (1988) argue that there were commonly accepted meanings associated with the term, specifically involving the conscious use of communication of information to help people form sound opinions and make good decisions.

A selection of alternative definitions is as follows:

- Agricultural extension is the process of enabling change in individuals involved in the primary sector (Vanclay and Leach, 2011)

- Agricultural extension services are common public sector support schemes that diffuse knowledge from the research centre to the practical field (Birkhaeuser et al. 1991)

- The role of extension is to communicate information to clients to enable them to improve their practices (Black 2000)

- Extension provides farmers with skills, management and attitudes to adapt to a context of continual change (Kilpatrick and Johns 2003)

- The purpose of extension is to improve farm performance by connecting emerging research with farm practices such as through the introduction of new technologies. It is a service that transfers specialist knowledge to farmers with the aim of achieving set objectives (Läpple et al. 2013)

In short, the primary task of extension is to help farmers improve their decision making (Van Den Ban and Hawkins 1988). This study draws on the definition of KT provided by Läpple et al. (2013) that the purpose of KT is to improve farm performance by connecting research with farm practices through transferring specialist knowledge and adopting new technologies to achieve set objectives.

Garforth et al. (2003) commented that most countries have established a form of public extension service for farmers funded largely from general taxation. Their role in enhancing the performance of the agricultural sector and supporting farmer income ensures some level of government funding for these programmes (Läpple and Hennessy 2015). Moreover, the ability of extension services to deliver KT is dependent on their support from governments to deliver the latest scientific research (Brown 1981; Headey et al. 2010). This public form of extension has since been supplemented by the private sector with the common objective of improving the performance of farmers.

*Policy: Why Intervene?*

Public extension agencies are more common for agriculture than other sectors of the economy mainly due to the fact that there are usually a large number of smaller enterprises which are unable to conduct their own research to improve the farm performance (Van den Ban and Hawkins 1988). The existence of agricultural extension relates to the need to assist in meeting the perpetual challenges for the sector in terms of productivity, environment, food safety, demographics, income support, rural development, and innovation (Kettering 2014). These are all strong market failure arguments for public extension services. The role of KT and agricultural advisers in general is important in facilitating policy makers to change farmer behaviour to address these challenges (Boyle 2008; Ingram and Morris 2007). Advisers assist farmers to overcome barriers that prevent them from achieving a set goal due to a lack of knowledge, motivation, resources, insight and power or a combination of these (Van den Ban and Hawkins 1988). Advisers need to respond to these emerging challenges, and continue to provide valuable effective advice to farmers.

These challenges indicate a need for extension providers to evolve and maintain their relevance with clients (Leeuwis 2004). Traditional objectives of extension to improve farm management and technology adoption have been supplemented by a focus on multi-functional agriculture, environmental protection, rural development and marketing. Extension providers must respond to these policy challenges with precise KT interventions to influence farmer behaviour. Van Den Ban and Hawkins (1988) referred to the dual objectives for governments in relation to extension to help farmers achieve their goals efficiently and to change farmer behaviour to align with wider government objectives. The Department of Agriculture, Food and the Marine (DAFM) manages the macro affairs of the Irish agricultural sector, but on a micro basis there is demand for assistance, and within this context extension organisations emerge. Thus, the department sets out the objectives and targets for the future, and then the agricultural sector must adapt to achieve these aims. Once the benefit of a KT intervention is recognised, positive spillovers are likely with the 'neighbourhood effect' of peer influence (Coccia 2008), which can be targeted in specific areas to augment impact (Läpple and Hennessy 2015).

This study focuses on the public extension provider in Ireland, Teagasc, and therefore accommodates the additional public policy objectives such as the wider range of goals and public goods outlined above (Kidd et al. 2000). However, it must be noted that the

approximately 40,000 public KT clients in Ireland are supplemented with a similar number of private KT clients (Kelly et al. 2013) which will fall short of 'public good' areas of extension services due to a prioritisation of individual consultant based work for their clients (Teagasc 2015). In addition, both the public and private sector extension services in Ireland have approximately 250 advisers each, but Teagasc receives public funding support (approximately 55%) whereas private extension organisations claim 100% of their funding from their clients and therefore prioritise the private benefits accrued to their client as opposed to developmental and public good based goals. Teagasc subcontracts some of its advisory services focused on private benefits such as the environmental GLAS programme to private extension providers. However, this study prioritises public KT due to its public good mission and the fragmented nature of the private extension providers in Ireland (Prager et al. 2016) with smaller private extension firms typically comprised of 1-3 advisers whereas Teagasc employs 250 advisers in its organisation (Kelly et al. 2013).

This difference in scale concomitant with the historical influence of Teagasc on Irish agricultural KT services could imply that institutional capture has occurred. This refers to the use of public resources to correct market failures and improve the economic status of specific groups (Stigler 1971). This can in turn create barriers for private extension providers to compete, and may raise questions over in whose interest Teagasc operates with the literature suggesting such institutions that were set up in the public interest may begin to serve private rather than public interests. The fragmented nature and typically smaller firms in private extension are unlikely to have the same level of resources to provide a service, particularly in relation to developing new knowledge based on conducting research. Similarly, the coordination problem of conducting research within a diverse farming sector is a key argument to justify the public expenditure rationale for supporting agricultural science more generally (Midmore 2018). This is a structural advantage for Teagasc that justifies the significant support received from the state to conduct research and deliver KT services based on the outcomes of that research. Teagasc also actively shares this research with private sector extension agents through Teagasc's ConnectEd programme (Teagasc 2018). This public support for science and extension is not viewed as a significant issue for this study as farmers are free to participate in both forms of extension and the prioritisation of public KT was based on the additional responsibilities for the service provision (Kidd et al. 2000). However, whether his support is proportionate in comparison with other areas of science, and whether the outcomes and

impacts identified translate to stakeholders beyond agricultural policy makers is questionable (Midmore 2018). Nonetheless, in the context of this study it is clear that institutional capture has not occurred, due to the objectives and funding structure of Teagasc, but this issue is explored in the qualitative analysis to investigate if farmers themselves are convinced of the validity of impact claims and their views on the reputation of Teagasc.

In short, public extension providers are influential instruments to achieve policy objectives by assisting farmers to implement new knowledge (Garforth et al. 2003; Ingram and Morris 2007). An efficient, flexible, functional extension body has the ability to complement this process by assisting at farm level across a range of outcomes, such as productivity, profitability, innovation, environmental mitigation, or social objectives. As such these organisations should be adequately resourced and supported by incentives to encourage participation to achieve policy objectives (Coccia 2008). The different types of KT activities are outlined in the following section.

*KT Type*

Black (2000) identifies 4 different types of agricultural KT activities:

1. Linear 'top-down' transfer of technology strategies based on the dissemination of information to farmers where it diffuses out among the wider farming community

2. Participatory 'bottom-up' approaches where farmers themselves are empowered to develop strategies in a networked environment for a collective goal as set by policy makers

3. One-to-One advice where the client meets on an individual basis with an expert who can explain new knowledge on a case-by-case basis

4. Structured education and training in which farmers can enroll and participate in a formal programme whether online or at an agreed location.

In more detail, Black (2000) describes the linear 'top-down' model as a more traditional form of KT services promoting the adoption of new agricultural technologies and management practices to improve performance in terms of an outcome such as productivity or profitability. It is considered a linear model as the advice is formulated by research scientists and policy experts, delivered by advisers to participating farmers,

initially embraced by more progressive or innovative farmers, and then subsequently adopted by the more reactive farmers in the community, similar to the linear model of diffusion (Padel 2001). It reflects the 'apprenticeship model' as previously discussed (Jensen et al. 2007). Critics of this approach argue that methods of farmers simply receiving the information and following instructions blindly are outdated (Garforth et al. 2003) as well as too rigid to accommodate innovative technologies (Morgan and Murdoch, 2000). Furthermore, the need for advisers to constantly assimilate new knowledge to deliver all possible solutions is unrealistic given the broad objectives involved and rigid nature of the top-down model (Farrell et al. 2008; Ingram and Morris 2007). Nonetheless, this is recognised as an important KT activity given the importance for farmers to learn new knowledge (Black 2000; Oreszczyn and Lane 2012).

The participatory 'bottom-up' approach has emerged as an increasingly popular form of agricultural KT in recent decades, with discussion groups as a prominent example. Discussion groups refer to groups of approximately 15 farmers that meet monthly on each other's farm to discuss a particular topic facilitated by the adviser. Membership can be renewed on an annual basis and farmers can deviate from the original topic to focus on the issues of most relevance to their farm. This approach encourages farmers to actively participate in the design and content of a KT activity which increases the likelihood of creating or leveraging knowledge by relying on the premise that farmers themselves will identify optimum solutions to problems (Blake 2000; Cliffe et al. 2016; De Long and Fahey 2000; Läpple and Hennessy 2015). This interactive networked environment enables the horizontal transfer of knowledge and sharing of ideas facilitated by an adviser which ensures a bidirectional or circular flow of knowledge in contrast to the linear method (Birkhaeuser et al. 1991; Garforth et al. 2003; Jensen et al. 2007). Indeed, this more dynamic approach based on a partnership between farmers and their peers as well as the adviser represents a shift away from the traditional method where advisers are seen as the only expert (Garforth et al. 2003; Ingram 2008).

This co-production of knowledge for transfer integrates new knowledge between multiple actors and is based on harvesting, translating and communicating new knowledge through a process that better ensures the uptake in innovation by end users (Purvis et al. 2014). By actively involving farmers in the design of KT their input can generate fresh views on the relevance of topics and formats within the process. Farmers are more likely to accept knowledge once they observe the value of such an action from their peers, as well as

identify solutions to challenges by working together as opposed to working independently (Cliffe et al. 2016; Hennessy and Heanue 2012).

The participatory format has developed in Europe over the past decade as 'knowledge networks' are established where farmer-led platforms encourage the exchanging of knowledge and innovations for practical uptake ad further adaptation (EIP-AGRI 2018). This collaborative approach facilitates learning, confidence building, motivation, and improved support (Garforth et al, 2003, Kilpatrick and Johns, 2003). However, the group based format may not be suitable for all farmers based on their preferences and particular need for advice. For example, farmers may be reluctant to discuss private matters in a group environment, or may be reluctant to share expertise to retain a competitive advantage on their peers (Garforth et al. 2003). This implies a need for a high level of trust between participants to realise the maximum benefits from these participatory approaches (Buck and Alwang 2011). However, this trust must be reciprocal between all participants as opposed to 'blind trust' where farmers accept advice without question (Morgan and Murdoch 2000).

One-to-one KT involves a transfer activity between two people whether from an adviser to a farmer or among farmer themselves (Black 2000). This type of KT activity may be considered an effective method to identify solutions to specific farm level issues as opposed to general advice on management principles. Taking grassland management as an example, the principles behind it such as grass measuring and rotational grazing are applicable in group based formats, but individual farmers may require specific advice to develop reseeding or fertiliser plans that requires one-to-one input. It has been argued that on-farm visits were best placed to support farmers in achieving an impact from KT due to the local expertise of the adviser as well as their skills at delivering knowledge in interpretable formats (Ingram and Morris 2007). However, this KT type incurs a higher economic cost than a group based format as it is more time intensive and the benefits are limited to the individual private user so it has been argued that this higher cost should be reflected in the fee paid by the farmer (Black 2000). For the purpose of this study, the one-to-one KT type is considered the same as the top-down format described above.

Finally, formal or structured education is also available to farmers, and much of the literature suggests that formal education has a positive impact on farm level outcomes (Cohen and Levinthal 1990, Heanue and O'Donoghue 2014; Kilpatrick 1996). It enhances management through superior decision making, improves information on

prices, and enables the adoption of innovative technologies (Reimers and Klasen 2013). However, a general reluctance to accept courses persist due to a variety of factors such as a lack of time, preference for practical rather than theoretical information, low confidence, awareness deficit, or uncertainty as to the relevance of the course on offer (Black, 2000). To find an appropriate formal education program that suits the heterogeneous preferences of the farming community is an omnipresent challenge for extension agencies.

Teagasc provides all four types as outlined by Black but the role of the participatory formats have increased in recent decades to complement the top-down traditional format often delivered through one-to-one consultations. Teagasc also provides a range of agricultural education courses for clients. However, for the purpose of this study the one-to-one consultations and discussion group activities were the key focus representing the top-down and participatory methods respectively. This is discussed in more depth in the qualitative analysis to investigate the impact of each activity on farm level performance.

In summary, each KT type has associated advantages and disadvantages, and given the heterogeneity of the agricultural sector (Morris et al. 2017), a 'one size fits all' approach is inappropriate (Garforth et al. 2003). Indeed, Black (2000) concludes that all four methods retain their importance, and hence, no single model will suffice without supplementation from another type. The diverse learning preferences of farmers must be accommodated to identify the optimal 'recipe' for KT that will lead to an impact (Kilpatrick and Johns 2003; Pasquini and Alexander 2005). It is important that multiple mechanisms are employed to promote farmer learning both through individual consultations with their adviser as well as through interactive formats with peers whether at a discussion group or other event (Ingram and Morris 2007). These KT types outline the range of activities that extension providers provide to farmers. To understand *how* impact is achieved from KT services, it is necessary to discuss the processes involved and this is the purpose of the following section.

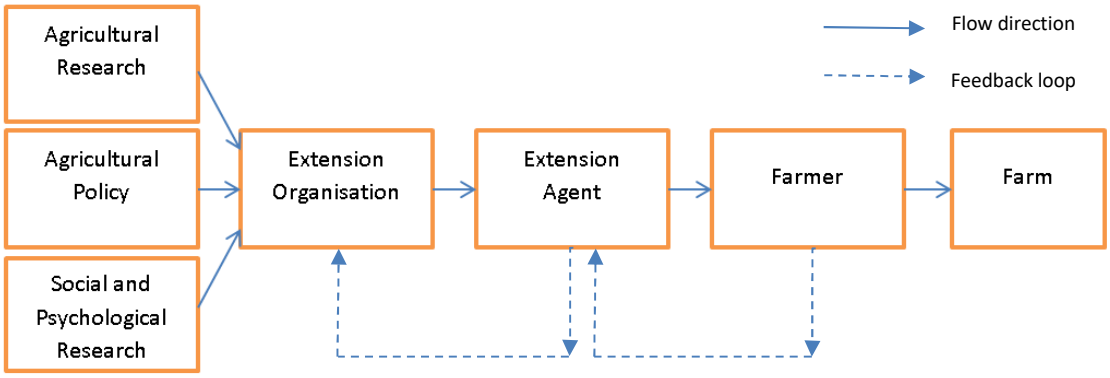
*The Process of KT*

Agricultural KT can be thought of as a 'systematic process' that assists farmers in multiple ways, including increased knowledge for problem solving and decision making (Van den Ban and Hawkins 1988). Birkhaeuser et al. (1991) summarise the process of extension itself as initially information is communicated across sources, followed by knowledge acquisition by recipients, and finally, if the perceived benefit outweighs the

cost, action is undertaken at farm level to improve farm performance. This perceived value of participation and resulting impact is likely to increase the uptake more widely as the knowledge is diffused to larger audiences (Padel 2001; Rogers 2010). KT services can operate under this framework with formal and informal networks employed as important environments to facilitate knowledge spillovers.

Van den Ban and Hawkins (1988) provide a simplified figure to represent typical knowledge flow in agricultural extension services as provided in Figure 4:

**Figure 4 Information Flow in Agricultural Extension**




Adapted from Van Den Ban and Hawkins (1988)

This illustration outlines a linear format for KT and identifies the role of the extension organisation, the individual adviser and the farmer in implementing new knowledge at farm level. The arrows show the traditional direction of influence from research and policy level, through the extension organisation and finally to where the knowledge is implemented at the farm level. However, in reality this linear format is flawed as the importance of the feedback effect is also crucial as farmers can actively contribute to policy design by communicating their knowledge in the process. This is represented by the dashed line which illustrates the reverse communication channel both from the farmer to the extension agent, and also from the extension agent to the extension organisation. For example, farmers can be viewed as co-producers of knowledge (Purvis et al. 2014) and will raise issues and concerns of most relevance to their circumstance to their adviser, who in turn then can communicate this to the extension organisation to influence the design of content. This is particularly relevant for Teagasc given the organizational structure that includes a research remit alongside the KT structure (Prager et al. 2016). Oreszczyn and Lane (2012) argue a holistic circular approach to knowledge flow for different contexts and between knowledge creators, users and intermediaries is more fitting.

Therefore, this study employs a variation of the Van den Ban and Hawkins (1988) model in Figure 4 but the linearity refers to the identified pathway to impact adopted although the importance of feedback loops and co-development of KT is also acknowledged. Specifically, this study focuses on the latter section of the chart with a particular emphasis on the role of the adviser and farmer in driving impact from KT, and accommodates some confounding factors that affect these boxes drawn from the Birner et al. (2009) framework for evaluation. The model and adapted model are discussed in depth later in this chapter. The roles of the adviser and farmer are discussed first for additional context.

**Role of Adviser**

Boisot and Canals (2004) argue that information and knowledge are commonly referred to as 'things', both stock and tacit, in economic literature that assist decision making processes. However, this relies on a strong assumption that they exist independently of a 'knower' or 'receiver', which refers to the personnel involved in the process of transferring knowledge. The extension organisation must ensure that KT programmes are relevant and aimed at audience demand, as well as ensuring the capacity to deliver the service in terms of resources and staff competency (Brown 1981).

*Capacity: Adviser Skills and Methods*

Within this capacity, the role of the adviser to translate complex material on emerging market trends, technologies, legislation and environmental awareness is essential (Ingram and Morris 2007). This expertise must be combined with their technical skills on management practices as well as their communication and interpersonal skills to connect with farmers, which represent the flexibility of advisers to sustaining the value of KT participation as advocated by Bogue (2014). Agricultural advisers operate as mentors to farmers and facilitate the sharing of knowledge, providing feedback and suggesting strategies to accomplish objectives which often suggests a new or alternative course of action (Bonaccio and Dalal 2006). The role of the adviser is to enable, organise and suppress barriers to effective knowledge flow (Paulin and Suneson 2012). This includes facilitating environments where knowledge spillovers are a positive externality to increase knowledge towards a desirable objective (Harris 2001). The capacity of advisers to deliver impactful KT services is a key aspect of the qualitative analysis to follow, particularly their methods to up-skill and to explain how their role has changed over time.

Indeed, this role has evolved from the top-down format of advising farmers to creating an environment for farmers to learn from each other. These environments enable farmers to act as 'knowing agents' and share their tacit knowledge with peers, creating additional knowledge spillover effects. The adviser must ensure effective communication both from themselves and among the farmers to ensure a shared objective is understood and met. This requires a broad understanding of social, technical and cognitive aspects of human organisations (Tuomi 1999). This form of cooperation among participants is imperative to knowledge negotiation through a social process conceived as 'knowledge in practice' (Bruckmeier and Tovey 2008). The discussion groups are a clear example of this participatory form of extension where advisers facilitate peer to peer learning within a group (Läpple and Hennessy 2015; Mahon et al. 2010). Participants communicate among themselves as well as interacting with the adviser in a structured and unstructured format that leads to collaborative learning (Cliffe et al. 2016). The internal/external divide of knowledge sharing described by Swart et al. (2014) can be thought of in this way as farmers may be considered internal with similar interests and host meetings facilitated by the adviser who may be considered external as an expert. Dillon et al. (2018) found that farmers were willing to share knowledge freely with peers in the discussion group format, but this may depend on an adequate level of trust.

*Trust*

The importance of trust is well established in the literature with Sheehan et al. (2014) noting the importance of 'bringing people together' and implementing a culture for learning and knowledge sharing purposes within an organisation. In an agricultural context Hansen (2015) argued that trust within a discussion group is crucial to sharing sensitive information and the role of facilitators in discussion groups is to encourage and challenge participants to share their knowledge to achieve maximum impact. Hennessy and Heanue (2012) concurr citing the role of the facilitator to generate a learning environment was imperative in participatory formats. Oreszczyn and Lane (2012) also commented on the extended web of influencers for farmers and how individuals act differently depending on their roles which are built upon their perceived trust and respect. The skill set required of advisers has evolved over time to develop this role of facilitation in networked events where they provide the tools to ensure knowledge is transferred effectively. This implies an increasingly fluid role of the adviser as extension services evolve from the traditional top down model where the adviser mentors and guides the farmer on an individual basis to group facilitation tasks (Garforth et al. 2003).

Trust between the adviser and farmer is fundamental to successful KT. The adviser develops a level of trust over time that is crucial to influencing farmer behavior towards a policy goal (Van den Ban and Hawkins 1988). The farmer must trust that the knowledge provided by the adviser is for their personal benefit and this trust can be more important than the message itself (Ketterings 2014). Advisers may be considered 'experts who will positively influence the performance of farmers (Cliffe et al. 2016; Lin et al. 2005). It is imperative that farmers do not suspect ulterior motives on the part of the adviser, creating a 'them versus us' mentality as described by Fisher (2013) when comparing the relationship between farmers and government representatives as opposed to farmers and veterinarians. For example, a farmer may question an unpopular or unproven policy and become frustrated if the adviser insists the policy is for their best interest, as opposed to an animal health issue raised by the veterinarian. The level of trust developed between advisers and farmers is easier to lose than it is to gain in the first place (Van den Ban and Hawkins 1988). This trust is built on the basis of a good rapport between participants underpinned by effective communication skills, which can help to portray the value of KT participation for farmers (Massingham and Massingham 2014). This is an important first step in the motivation of farmers to engage with KT.

This complex role of the adviser is a prerequisite for impactful KT and warrants further investigation to understand their role within the KT process and how this role has evolved as well as the perceived importance of trust to underpin the relationship between KT and farm level impact. This is a key objective of the qualitative analysis.

**Role of Farmer**

The role of the adviser represents the preparation and delivery of knowledge in the KT process, but ultimately whether it makes an impact on farm level depends on the role of the farmer. The farmer must decide to participate in the first instance, then to engage fully and learn, followed by implementation on farm that leads to impact. Each step is now discussed in turn.

*Motivation to Participate in KT*

The motivation to participate is a key factor of KT as farmers decide on the value of participation which is influenced by a variety of factors. For example, farmers may wish to improve their performance to increase profitabilty through KT interaction, or for a social benefit of meeting other farmers. Short term and long term objectives require

different incentives to encourage participation (Massingham and Massingham 2014). Their motivations are diverse shaped by their personal characteristics which reflect the heterogeneity of the agricultural sector. Vanclay (2004) argues that a variety of diverse principles shape farmer decision making processes including their attitude to social, economic and personal development objectives. For example, 'farmers are not all the same', 'profit is not the main driving force of farmers', and the 'stage in life and family cycle are significant factors in farmer decisions' were identified as categories within the study. Financial incentives may attract farmers that otherwise would not participate but there is evidence that their subsequent impact is lower than farmers who participate regardless of the incenvtive (Läpple and Hennessy 2015). Farmers who are motivated by the recognition of a value to their participation in terms of improving their farm performance achieved higher outcomes, and are also more likely to renew contracts with the KT provider.

The motivation of participants to learn is the first step towards achieving impact and depends on their perceived value of that participation (Butler et al. 2007). Ketterings (2014) implied that farmers will engage once they recognise a 'win-win' outcome for their participation. These motivations are affected by various factors including the urgency of an issue, self-efficacy, complexity, observability, trialability, clarity and consequences (Leeuwis 2004). However, the inclusion of farmers in the design of KT objectives has shown a greater participation rate as farmers have more influence on which content which in turn can lead to a greater probability of impact through bidirectional learning (Hagger-Johnson et al. 2013; Walker et al. 2009).

Once farmers have decided to participate in KT programmes, the next step is to decide what level of engagement is preferred. The various KT types as outlined by Black (2000) show that a 'one size fits all' approach is inappropriate as farmers preferences vary. The one-to-one consultation format is based on the top-down format which implies learning directly from the adviser. In contrast, the participatory format of KT discussion groups involves a high level of social interaction, and this can be a valuable source for knowledge creation and the horizontal transfer of this knowledge (De Long and Fahey 2000). The group based format entails an additional responsibility for the farmer to share their knowledge with peers to increase the impact of the group in KT. Formal and informal KT occurs in these environments as a result of the networking that takes place (Grimpe and Hussinger 2013). The adviser acts as a facilitator by bringing information on the latest

research findings and market developments to their attention, and then they discuss practical issues among themselves, which also builds relationships (Dillon et al. 2018).

The issue of knowledge sharing has been explored in the literature, with Swart et al. (2014) noting that the commitment of an employee in an organisation was based on the underpinning trust and this affected their willingness to share knowledge both internally (amongst colleagues) and externally (to outside the organisation). De Long and David (2000) also explored the effects of trust on knowledge flow within organisations, and found a relationship between high trust cultures and increased flow, although they found a difficulty with external knowledge sharing particularly with individuals feeling a loss of ownership when inputting information on computer databases.

In an agricultural context, this suggests that knowledge sharing is more likely within the group if it is a trust based environment both with the adviser and with peers. Conversely, a lack of trust is likely to reduce the willingness to share knowledge due to a feeling of exclusion or isolation among group members (Fisher 2013). This can be based on the compatibility of group members (Ingram and Argote 2000). These issues are explored further in the qualitative analysis to identify the factors that are most influential in incentivising farmers to participate in KT.

*Learning*

The importance of learning in the KT process is key to adopting new technologies and management practices. The education and experience of the farmer can aid this process. Previous education, particularly agricultural education, has been used as a proxy for farmers attitude towards learning (Läpple and Hennessy 2015), and there is evidence of agricultural education resulting in positive income effects on the farm level (Heanue and O'Donoghue 2014). In addition, it has been argued that experience of previous KT interactions increases the probability of future participation (Butler et al. 2007), as well as fostering a proactive problem solving approach (Hansen et al. 2014).

Although the difficulty of any task is inherently relative (Baumann and Bonner 2011), a higher level of education is expected to benefit KT related learning. Education provides farmers with the capability to adjust to market disequilibria brought on by technological change (Heanue and O'Donoghue 2014), which can be combined with their experience to implement new knowledge to improve performance (Hansen 2015; Torock 2009). A level of background knowledge is necessary to absorb new knowledge and translate its

applicability to individual contexts (Bruckmeier and Tovey 2008). Learning depends on what people already know, and what they can interpret from new knowledge to implement this learning (Hansen 2015), but this must be combined with the motivation of the individual to improve (Minbaeva et al. 2003). Van den Ban and Hawkins (1988) argue that teaching a farmer to apply self-directed learning was key in developing their problem solving skills as well as reducing their reliance on their advisers. However, learning is a complex process that combines cognitive, emotional, environmental influences, and experiences that enable change in the individuals' skill base, or knowledge stock (Hansen 2015). The ability of farmers to learn in the KT process is dependent on their level of absorptive capacity.

Absorptive capacity has been defined as the ability to adopt new knowledge and apply it for commercial gain (Cohen and Levinthal, 1990). Coccia (2008) defined absorptive capacity as the amount of knowledge a firm can use economically. In an agricultural context, this can be transferred to how a farmer learns new knowledge and implements it on their farm to achieve improved economic results. Klerkx and Leeuwis (2008) argue that farmers required greater absorptive capacity to acquire, learn and initiate more to ensure successful knowledge transfer, particularly with regard to innovation. The level of absorptive capacity varies as does the level of learning possible (Coccia 2008), but the motivation to learn is the key driver of impact (Leeuwis 2004). This level of absorptive capacity can be developed, and there is evidence that it increases in a participatory KT format (Aalbers et al. 2013). However, a lack of absorptive capacity can also prevent impactful KT which results in a lack of knowledge gained (Paulin and Suneson 2012). Nonetheless, once new knowledge is learned, and reflected upon to decide on the value of taking action, farmers are more likely to implement this new knowledge on their farm (Torock 2009).

The learning preferences of farmers are diverse which is reflected in the KT types as outlined by Black (2000). The one-to-one method continues to hold its importance for the private acquisition of individual advice and is highly valued by farmers (Ingram 2008; Kilpatrick and Johns 2003). Participatory methods have been credited as effective on the basis of a shared inclusive objective, access to the scientists and advisers as well relevant and interesting content (Sewell et al. 2014). This also implies the reverse where farmers lose interest in irrelevant content or an overload of technical content. The participatory method facilitates social learning where participants become aware of an initiative, before becoming interested, participating and establishing new practices and routines (Leeuwis

2004). This is in contrast to the traditional top-down paternalistic model where the adviser is expected to provide all solutions as an expert (Mahon et al. 2010).

Social learning occurs in both formal and informal settings with behavioural change linked to the observation, imitation and replication of knowledge (Nyanga 2012). This can be particularly powerful when considering the adoption of new technologies (Krishnan and Patnam 2014). Indeed, the emergence of discussion groups, demonstration farms, farm walks and other similar events provide a fostering environment for the socialisation phase, where farmers can observe, imitate and practice new techniques, as well as share their knowledge and experience. These participatory formats of KT have been credited as particularly conducive to the diffusion of knowledge, particularly with regard to tacit knowledge (Harris 2001; Noorderhaven and Harzing 2009). Lwoga et al. (2010) found that farmers learned most from socialisation with advisers and peers as opposed to externalised written documentation, with local informal social networks cited as important for knowledge retention and transfer. Their analysis implied that advisers had an important role in providing a structured environment to facilitate interactive KT participation which relies on social capital which is consistent with the discussion group format of KT. This concept of social capital is useful to examine the process of learning, particularly in the context of social or interactive learning which occurs in the participatory KT method. Social capital occurs when participants unite to achieve a common goal of learning for a particular objective (Legun 2011; Svendsen and Svendsen 2004).

It may also be argued that farmers operate under a 'learning curve' or 'experience curve' with increased learning in earlier stages of a career before tacit knowledge built up reduces the reliance on KT participation. In the management literature, there are examples of concomitant learning benefits through a 'practice makes perfect' approach that reduce costs later such as the technology adoption (Coulomb and Neuoff 2006; Massingham and Massingham 2014). This form of endogenous learning spreads as technologies and practices become more frequently adopted by farmers (Genius et al. 2013). However, this 'learning by doing' approach may be subject to the homogeneity of the material being learned, especially when the diffusion of learning is considered (Thompson 2001). This could apply to particular management principles for farmers but would vary on each farm. For example, a new reseeding plan is likely to follow explicit principles but will affect farms differently once implemented depending on soil capacity. Nonetheless, farmers who reflect on the knowledge they have learned are more likely to recognise the benefits

and implement the knowledge based on their experiential learning (Torock 2009). This is a challenge for farmers as KT content may not be homogenously applied. The learning preferences of farmers will be explored further in the qualitative analysis, particularly in relation to the type of KT activity whether in a discussion group environment or a one-to-one consultation as most suitable to encourage learning.

*Motivation to Implement New Knowledge*

Evaluating the impact of the KT process depends on the implementation of the newly acquired knowledge at farm level. This is represented by the 'taking action' stage in the Daft and Weick 1984) model as illustrated in Figure 3. The implementation stage occurs once the knowledge has been learned and accepted as beneficial by the farmer. It is a result of a rational decision making process (Ketterings 2014). This occurs in the farm household (Birner et al. 2009), and involves an evaluation of the value taking action based on what has been learned (Butler et al. 2007). This decision making process is likely to vary across all farmers based on their diverse characteristics and motivations (Vanclay 2004). However, the relevance and practicality of the advice and the connection of that advice to farmer local conditions and expertise is likely to increase the implementation of new knowledge (Ingram 2008).

The influence of both the adviser and peers are important factors in the utilisation of advice (Yaniv et al. 2011), as well as the content of the advice whether the advice is on *how* to make a decision or advice on *what* to decide (Bonaccio and Dalal 2006). This study simplifies the content of advice down to the specific management practices of grassland management, breeding management and financial advice to ensure consistency in the interviews, but this variation in the type of advice is worth noting. For example, a decision on which bull to select for breeding reflects the *what* type of advice whereas the process in deciding on a financial plan is more representative of the *how* to use advice in an individual scenario. Nonetheless, the utilisation of advice from advisers and peers has shown to improve subsequent decision making (Yaniv and Milyavsky 2007). However, this advice may be rejected or modified if not fully understood (Ingram 2008).

The implementation of knowledge is not commonly addressed in the literature with many studies focusing on the delivery of the service or the methods of learning (Ingram 2008; Kilpatrick and Johns 2003). Qualitative research can address this gap by deepening our understanding of the influences, mechanisms and motivations that drive farmer decisions

to implement the knowledge (Macken-Walsh et al. 2012). This is a central research objective addressed in Chapter 6 to identify the drivers and barriers to the implementation of newly acquired knowledge. Specifically, the content delivered in KT interactions, the activity most suited to influence implementation and the role of the adviser are investigated to improve our understanding of how KT impact can be achieved.

**Challenge of Evaluating Impact**

Providing evidence of impact from KT activities is a key challenge for extension organisations particularly in the context of delivering value to funders for policy makers with competition for resources (Kidd et al. 2000; Midmore 2017). As a consequence, the number of studies in recent times on evaluation has increased (Faure et al. 2012). Evaluation is an important tool that can help organisations learn what works well and what does not (Norton et al. 2016). However, there are a number of challenges associated with assessing the impact of KT activities such as the phase of the farmers' development cycle, policy and market influences and information flows (Birkhaeuser et al. 1991). Typically, the results of evaluation vary significantly given the range of methodological options available coupled with contrasting outcomes (Anderson and Feder 2004; Läpple and Hennessy 2015; Midmore 2017). Furthermore, there has been a lack of consensus on the definition of impact itself. Indeed two significant barriers for impact evaluations on rural related issues are to agree on a specific measure of outcome, and the challenge of agreeing a precise definition within an evaluation model (Hodge and Midmore 2008).

There are also theoretical complexities surrounding evaluating KT impact given the pluralistic nature of extension services and the associated methodological approaches (Hagger-Johnson et al. 2013). A theoretical framework is necessary to refine the focus into a meaningful form to identify a 'best-fit' model as advocated by Birner et al. (2009). Midmore (2017) discusses the various pressures that exist to represent impact with formative purposes to understand why an impact is produced or not and involves experiential learning for those involved, whereas summative purposes aim to attribute impact to the inputs that supported it. While both methods can be argued as valid, the interpretation of impact varies with each. One is driven by the desire to achieve a societal impact, whereas the other implies an accountability objective which is essential for securing future funding. Indeed, decisions related to resource allocation can be subject to rigorous evaluation of projects and initiatives that foster this increased level of accountability (Norton et al. 2016). To evaluate the impact of a particular policy initiative

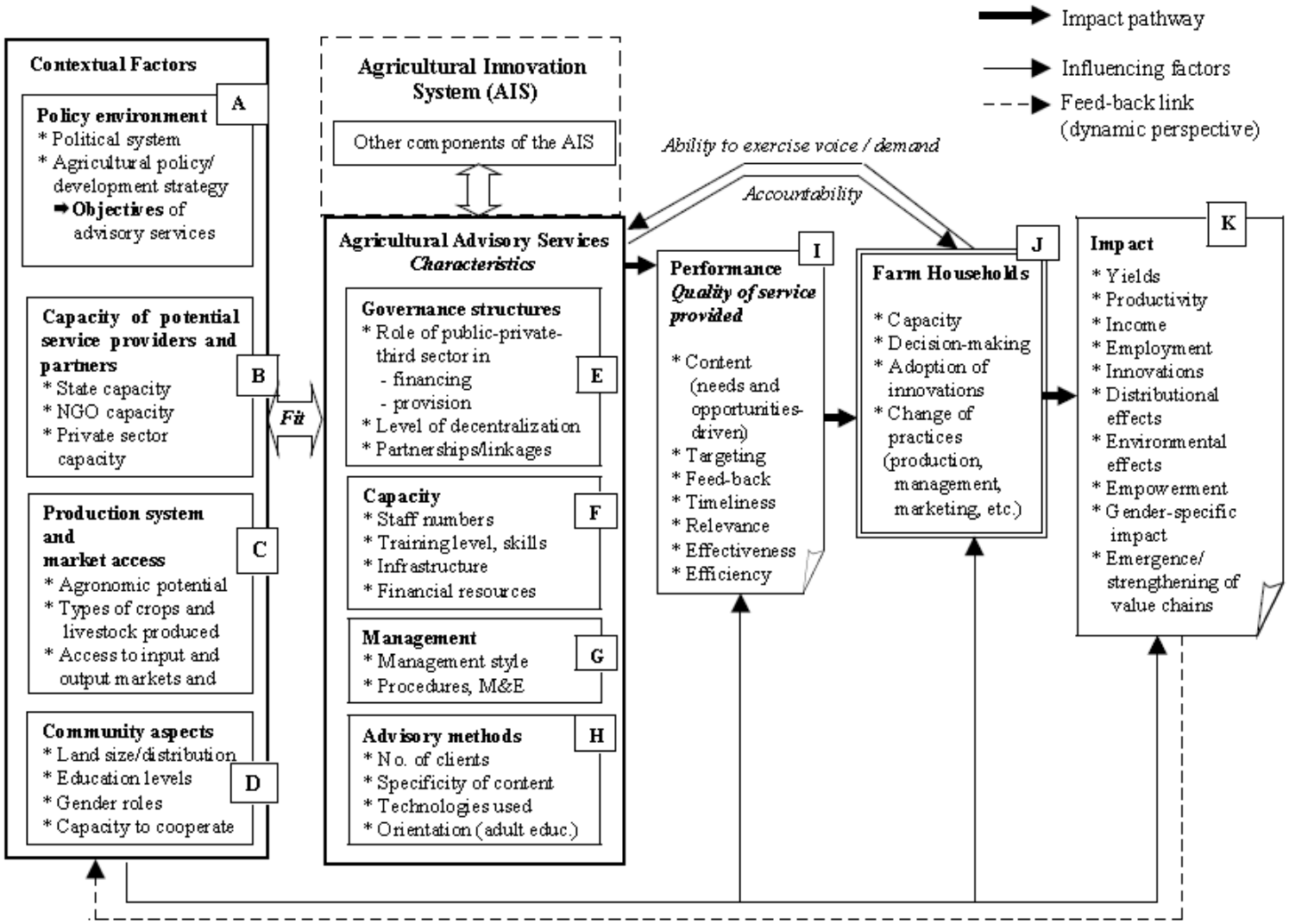
can also vary based on the purpose of evaluating the effort (level of inputs), performance (level of outputs), efficiency (outputs from inputs), process (methods and procedures), but to measure the effectiveness (achieve intended societal goals) of a policy may be the biggest challenge (Howlett and Ramesh 2003). The methodology to measure impact will therefore vary depending on the purpose of the impact, but pluralistic methodologies must be integrated to ensure progress in evaluations to improve accuracy and validity of studies (Midmore 2017). Although there may be implicit epistemological conflicts in combining distinct empirical approaches, identifying an approach that allows for complementary insights can deepen the overall understanding of a particular issue (Hamade et al. 2015).

The accuracy of evaluations is also a significant challenge with multiple confounding factors that can cause bias within estimates which can lead to incorrect inferences on the level of impact (Abdallah et al. 2015; Akobundu et al. 2004). These biases are caused by the endemic issue of endogeneity caused by omitted variable biases, measurement error or self-selection biases caused by inherent differences between participants and non-participants (Hennessy and Heanue 2012). An endogenous explanatory variable exists when the variable is correlated with the error term (Wooldridge 2013). This means that the estimated coefficient for that variable will be inconsistent and biased as its magnitude is somewhat determined by the unobserved variables. Coupled with this challenge is to explain the underlying factors that affect each phase in the process of KT to achieve impact, to enhance our understanding of the incentives and barriers to implementing effective knowledge on farms. This informs policy makers and stakeholders on the mechanisms that are most relevant at driving impact, and can only be explored through qualitative investigation (Faure et al. 2012). These challenges are overcome through methodological solutions that are discussed in more detail in chapter 3. The framework that has been adopted to conduct this study is presented next to illustrate the evaluation approach.

*Organisational Framework*

Birner et al. (2009) provide a useful framework that outlines the complexities and interrelationships among various factors in the provision of agricultural KT. This framework can be adapted to focus on a specific impact pathway from the KT provider to the farm level outcome of interest. The framework also facilitates feedback loops that show the bidirectional nature of influencing factors. This framework outlines options for researchers to identify their 'best-fit model' and has been adopted in evaluation studies where authors select the key variables to focus on (see Faure et al. 2012 and Prager et al. 2017 for examples). The Birner et al. (2009) framework is illustrated in figure 5:

**Figure 5 Organisational Framework (Birner et al. 2009)**



Evidently it is challenging to accurately assess the impact of agricultural KT given the complex operational environment, pluralistic objectives, heterogeneous participants and the diverse range of outcomes. However, within this range of factors, the focus can be refined by isolating specific variables. This study adapts this framework to identify the key variables of focus while acknowledging the influence of excluded factors. Each aspect of the framework is now described in turn with their specific relevance to this study.

The contextual variables outlined in the first column illustrate the influencing factors that shape how the KT bodies perform their duties. Contextual factors can only be influenced indirectly, if at all, by policy makers or KT management (Prager et al. 2017). Objectives and budgets are set from the policy environment (box A) which the KT authority aims to deliver dependent on their capacity (box B). The latter two boxes orient the type of advice provided based on the needs and demands of the farmers (Faure et al. 2012). This study focuses on the public KT provider in Ireland, Teagasc, which operates as the sole public agricultural KT provider in Ireland. Teagasc is tasked with providing support to farmers to manage their technical demands as well as the policy goals set by the EU and national government in relation to the emergent multifunctional agricultural sector (Laurent et al. 2006). It is defined as an autonomous state body, but relies on public funding to supplement its operation ensuring it has the capacity to deliver on its objectives. In terms of boxes C and D Teagasc forms strategic alliances with selected partners to ensure research findings, policy goals and market conditions are communicated across a range of forums to reach their clients.

The second column identifies the factors that contribute to the organisational structure. The governance structure refers to the institutional set up (box E) whereas the capacity, management and methods (boxes F, G, H) describe the allocation of resources (Faure et al. 2012). The Agricultural Innovation System (AIS) based on networks is a significant influence on the organisational structure of KT providers. Teagasc has developed strategic linkages with industry based partners, government agencies and educational institutions, but could further develop their networks with private advisers and specialists (Prager and Thomson 2014). The management system includes the type of KT activity employed along with the planning, monitoring and a system of evaluating performance (Birner et al. 2009). These evaluations are based on the performance of the KT provider as opposed to the recipient. For the purpose of this study the management box is merged

with 'performance' column to identify the influence of each KT activity and content where the KT interaction is carried out.

Accordingly, the third column looks at 'performance' and is measured based on the quality of service provided (box I) with an emphasis on client feedback and resource efficiency. Performance could suggest an outcome from a KT interaction but in this context it refers to the delivery of the KT interaction. The relevance of programme content is a key factor in motivating farmers to participate as well as the role of the adviser to translate and communicate knowledge into workable formats (Ingram and Morris 2007). The performance column does not capture the decision making process of farmers. Instead this process occurs in the fourth column 'farm households' (box J). This box is less common in evaluations given the difficulty of acquiring reliable data. This research aims to bridge this knowledge gap by qualitative exploring the motivations of farmers to implement newly acquired knowledge at farm level. This decision is influenced by the perceived benefit of learning the advice and taking the recommended action (Butler et al. 2007; Ketterings 2014).

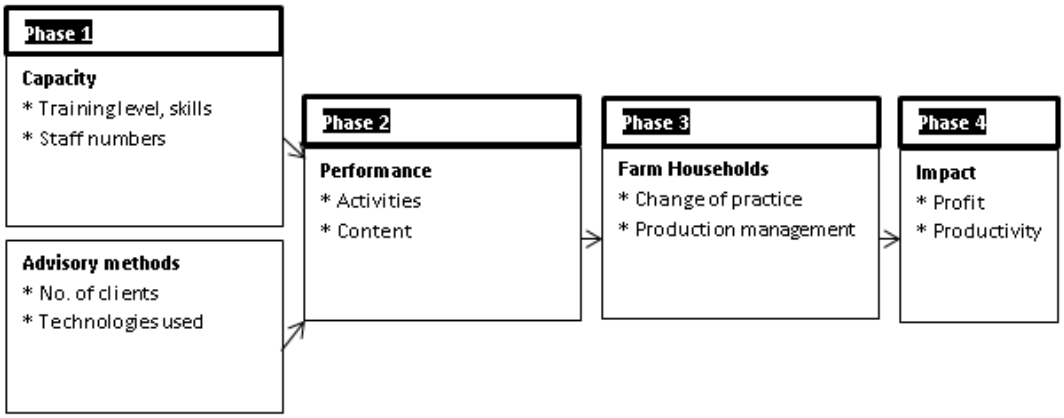
The final column of impact is the key area of focus for this research. In order to evaluate the impact of KT participation on farm level, this study quantitatively measures the change in financial performance for participants as well as qualitatively exploring the underlying factors that drive this impact. The various other factors that affect impact as listed in the framework are also important, but it is prudent to refine these to outcomes that are measurable given the available data. Furthermore, by focusing on financial performance, this research ensures that the outcomes are provided in a format relevant to all types of farming enterprises. The quantitative analyses examine both farm income and farm margins to distinguish the subsidy effect from returns to production, with specific enterprises more reliant on support than others. The qualitative analysis also considers productivity which is closely aligned with profitability when exploring examples of KT related practices implemented on farm level.

*Condensed Framework*

This research adapts the framework of Birner et al. (2009) to identify a pathway to KT related impact on farm level. The Birner et al. (2009) framework includes all variables that can influence the process of KT but is unrealistic to apply to an individual study, particularly given the range of impacts identified. Therefore, specific variables were chosen on the basis of identifying a pathway to impact that helped to organise the analyses of this study. Specifically, this model outlines the variables considered and adapts the model to represent a simplified version of the KT process divided into individual KT phases. Notwithstanding the various other confounding factors that affect the KT process and the dynamic feedback links in the original model, the adapted model isolates key factors that are organised present a model to conduct these analyses.

Accordingly, this research focuses on the capacity (box F), and advisory methods (box H) on the adviser side to represent the organisation of the KT service in preparing the specific programmes and content. Next, the performance (box I) is chosen to represent the phase to where the KT interaction is carried out. This phase focuses on the specific KT activity and relevance of the content to increase the likelihood of farmer implementation. Next, the framework focuses on the farm household (box J) where farmers decide to utilise the advice and implement the new knowledge. Finally, impact is measured as the change in profitability and productivity (box K). The adapted model organises the Birner et al. (2009) framework as a series of phases where KT is designed in the first phase, performed in the second and implemented in the third to lead to an impact in the fourth. The impact of KT is measured in terms of farm income in the first analysis and profitability in the second distinguished on the basis of including subsidies or not. The qualitative analysis is broader in that it also examines financial performance but this is also related to productivity. Key themes such as KT impact, the motivation to participate and the management of KT delivery are central to achieving this additional insight. This ensures a coherent approach to evaluation that provides a valuable contribution to the literature. The condensed version of the framework is provided in Figure 6:

**Figure 6 Condensed Framework**




*Adapted from Birner et al. (2009)*

In more detail this study adapts the Birner et al. (2009) framework to identify a pathway of KT impact including the provision and delivery of the service, the decision of the farmer to utilise and implement the advice and the resulting outcome from that decision. The capability of the KT organisation and individual adviser to provide and deliver the service is mirrored with the learning, implementation and impact on farmer performance. The pathway is based on a series of outcomes from these individual phases. These include the capacity to deliver the service, the mix of KT activity types necessary to engage farmers and the resulting utilisation of new knowledge at the farm level are the key factors identified to achieve impact. It is important to acknowledge that agricultural KT operates in a complex process as evident in the Birner et al. (2009) model, that defines KT and innovation as a co-evolutionary and interactive learning process that involves a wide range of actors in multiple social networks (Bonfiglio et al. 2017). The condensed model used in this study focuses on selected variables to identify a pathway of impact to quantify the level and explain how that impact was achieved.

The first phase is based on the ability of the provider to meet the client demand for their service. The means of advisers to up-skill their expertise is described as well as the number of advisers and clients in each office. This phase also includes the methodologies available to advisers to deliver the content demanded by clients which includes designing the programmes, activities and utilising information and communication technologies (ICT). Within this context, Teagasc has adjusted its traditional top-down model of KT support based on 'service based duties' such as scheme applications equated with private goods at this time to fulfill a more participatory format of 'brokering' or 'innovation support' role that involves a broader and deeper level of expertise to affect change at farm

level as well as augmenting the public good nature of the service (Teagasc 2016). Indeed KT itself has been described as a precondition for innovation as it creates partnerships and builds capacity to overcome challenges and develop policies (Bonfiglio et al. 2017). The increasingly nature of participatory formats of KT through discussion groups and events in recent decades are central to this functional change (Garforth et al. 2003). This change in ethos involved a rethink of the allocation of resources to achieve impact when designing KT models.

The next phase indicated by the arrows is the performance which involves the KT interaction with clients. This is the stage at which the knowledge transfer process is delivered through a particular activity such as mass events, demonstration farms, discussion groups or one-to-one consultations. Advisers determine the content on the basis of both the organisational objectives as well as the demands of the farmer which can vary from general principles on management to specific individual needs. For the purpose of this study the content refers to specific technical based advice on grassland and breeding management, as well as financial advice. The relevance of the content as well as the learning preferences from each KT activity are explored in the qualitative analysis.

From these stages, the process of KT moves towards the impact stage where the farmer ultimately decides whether or not to implement the new knowledge. For example by adopting a new technology they have learned, or applying a new management practice indicates the implementation of newly acquired knowledge. The adoption of innovative based practices is critical for agricultural development and is a key factor in understanding how farm households operate and remain viable (Morris et al. 2017). The result of this decision to implement is the key focus of the analysis in order to explain the impact achieved at farm level in terms of profitability and productivity. It is important to stress that these are the key areas of impact focused on in this analysis, although there are many others including environmental, social and complexities within the value chains which are present in the Birner et al. (2009) model, but outside the remit of this study.

This condensed version of the Birner et al. (2009) model therefore refines the focus of the study to examine four key selected phases of the KT process to evaluate impact. The qualitative analysis utilises this framework to examine the key themes raised in this chapter, namely the role of the adviser in preparing and delivering the KT content, and

the role of the farmer in participating, learning and implementing new knowledge to achieve impact.

**Conclusion**

This chapter presents the theoretical background from which this study is undertaken. Knowledge as a resource and the transfer of that knowledge were defined in the context of agricultural KT with a particular emphasis on the challenge of transferring tacit knowledge. The role of the adviser in the KT process has evolved from the traditional role as the expert that translates new knowledge into workable formats for farmers to include a facilitation role for group based KT. However, the experience of this evolution is not well documented in the literature. Similarly, farmers are characterised by diverse motivations, and learning preferences and a 'one size fits all' approach to KT may be unsuitable. To improve our understanding of the motivations of farmers to participate in KT, to understand their preferences for learning and persuading them to utilise the advice and implement new knowledge are the key stages within the KT process and their impact at farm level is the key objective of this study. This will enhance the existing literature by identifying the key drivers and barriers to KT impact as well as investigating the content and activities most effective at achieving impact.

The complexities of evaluating the impact of a KT service are challenging as a result of the pluralistic objectives and disparate range of outcomes and therefore require an appropriate methodology to deliver meaningful results. The methodology for this study is developed by adapting the framework for KT evaluation provided by Birner et al. (2009) to identify a pathway to impact that refines the focus of this research, notwithstanding the importance of other variables and the dynamic nature of the KT process. Furthermore, the application of both quantitative and qualitative methodologies is appropriate to address the research objectives, namely to measure *what* the level of impact is and *how* that impact is achieved. The rationale and approach for this is the purpose of the following chapter.

# Chapter 3: Methodology

## Introduction

This chapter provides an overview of the methodology used in this study, namely a multi-methods approach. The research objectives require a methodology that can explain both the level of impact achieved on farm level for participation in agricultural knowledge transfer (KT), and the underpinning factors that lead to this impact through the process of KT. A multi-methods approach is most suitable to address these objectives as the quantitative analysis can measure *what* the level of impact was and the qualitative will provide insight into *how* this impact was achieved. Multi-method analysis enables the research objectives to be addressed by encompassing both forms of enquiry to fill the gaps inevitability left by each mono method alone (Bryman 2008; Johnson et al. 2007). The rationale for the multi-methods approach as well as an overview of each phase of the analysis is presented in this chapter.

## Philosophical Perspectives

All research is situated in a particular social context underpinned by a chosen philosophical perspective or research paradigm. Within these perspectives research methods emerge which are determined by their specific objectives. Creswell (2009) referred to these as 'worldviews' that are inherently held by the researcher and shape the way the research is designed. The assumptions of the researcher may have salient implications for the conceptualisation and implementation of the research (Plano Clark and Ivankova 2016). For example a positivist approach is commonly associated with quantitative research based on the objectivity and generalisability of the technique. Conversely, an interpretive approach is more common for qualitative analysis where meanings are interpreted from the data collected to explain a particular phenomenon. These implications are particularly important for multi-methods research where different approaches are integrated within one study (Plano Clark and Ivankova 2016). This study primarily adopts a positivist approach to utilise both methodological approaches to gain an improved understanding of the impact of knowledge transfer on farm level. The following sub sections provide the rationale for this choice by defining each perspective and discussing their usefulness in addressing the research objectives.

*Positivism and Post-positivism*

Bryman (2008) defined positivism as "an epistemological position that advocates the application of the methods of the natural sciences to the study of social reality and beyond." This entails a number of principles including the use of theory to determine testable hypotheses, acquiring knowledge through factual data collection and above all that positivist research must be objective and free from normative assertions (Bryman 2008). The personal values of the research do not influence the outcomes of the research. The post-positivism approach is similar to the positivist approach but challenges the generalisability of results due to the type of data used. Both positions assume a single reality that can be observed objectively (Plano Clark and Ivankova 2016) as well as drawing testable models from theory (Cresswell 2009) but differ on the strength of their findings and implications with post-positivists preferring to reject a hypothesis than claiming proof (Creswell 2009). Positivists may have difficulty in conducting both quantitative and qualitative methodologies based on the inherent differences and assumptions likened to both. Post-positivists sidestep this concern of ontological and epistemological contradictions in both methodologies by arguing that all data-sets are open to interpretation (Fielding and Fielding 2008). This study follows this argument in that the analysis is conducted to address a single research topic through both methodologies sequentially.

Given that the initial phases of this research are based on quantitative analysis, a positivist approach is applied in those cases. The level of impact identified follows established quantitative analysis techniques to ensure objectivity and the data is based on a panel data set which is representative of approximately 100,000 Irish farms per annum. Therefore the findings can be generalised to a significant proportion of farms in Ireland over a 15 year time period. In addition, the qualitative approach adopts a positivist stance by accommodating theoretical considerations to outline behaviour and attitudes that are used to identify the key variables used in the qualitative analysis. This is achieved through a process where the researcher collects detailed data from participants which are then formed into categories and themes to answer a specific research question (Creswell 2009). This is the stance adopted in the qualitative analysis which is explained in more depth in chapter 6. The theories generated in the theoretical discussion in chapter 2 will be tested in the qualitative analysis which is a valid approach to address the research question (Bryman 2008).

*Realism*

Realists apply two forms of realism in their approach, namely naïve realism or critical realism. Both forms are similar to positivism in terms of data collection and deductions in that their descriptions of reality aim to reflect the true reality, but differ on the basis of recognising the underlying factors or structures that cause this reality (Bryman 2008). Realism acknowledges the influence of unobserved confounding factors in their findings. This includes the researcher's own constructed reality through their personal values within the research and therefore emphasises the importance of the context in drawing their conclusions (Plano Clark and Ivankovo 2016). A realist approach merited consideration when choosing the methods to address the research objectives of this study, given the importance of confounding factors in measuring impact. However, the quantitative methodology employed adopts techniques to control for these confounding factors and the qualitative analysis aims to include these factors in the KT process for additional insight.

*Interpretivism*

Interpretivism is commonly applied as an alternative to positivism that relies on strategic interpretation of the diverse subjective meaning among individuals (Bryman 2008). The focus is based on understanding aspects of human behaviour as opposed to quantifying a particular relationship, and as a consequence is more common in qualitative analysis. An interpretivist approach explores the underlying processes that drive specific social actions and inevitably can vary widely among heterogeneous observations and experiences. Whilst interpretivism could have been employed for the qualitative analysis in this study, it is unsuitable for the quantitative aspect, and therefore was not appropriate for the overall approach.

*Constructivism*

Typically associated with qualitative research, constructivism prioritises the participants' view of the situation being studied (Creswell 2009). The researcher must allow for multiple realities as opposed to the single reality associated with the positivist approach (Plano Clark and Ivankova 2016). Given the complexity of the KT process and the wide ranging outcomes to measure KT impact as discussed in the Birner et al. (2009) framework, the methodology chosen for this study refined the focus to an identified pathway of impact. The quantitative analysis follows established methodologies to

identify the level of impact. The qualitative analysis uses this framework to guide participants' responses although the semi-structured format of interviews did allow for participants to elaborate on key themes if necessary. On this basis a constructivist approach was not adopted for this study.

*Advocacy and Participatory Perspective*

This approach formed from the gap in the constructivist stance that fails to recognise the role of marginalised individuals. Accordingly, this approach can be intertwined with a political agenda to actively seek to improve the situation for specific participants (Creswell 2009). For example a researcher may study unemployment rates in disadvantaged regions with a view to promoting the challenges using the voices of those affected. However, given the nature of the research objectives these perspectives were unnecessary in this study.

*Postmodernism*

Advocates of this philosophy acknowledge that reality is chaotic and unstructured and therefore the values imposed by a researcher are limited to their own assertions and no better than the values of another researcher (Plano Clark and Ivankovo 2016). Whilst there may be merit in applying this approach in particular cases, it is difficult to dismiss the alternatives that provide a structured discourse to situate research to address the research questions. Accordingly, this approach was not considered for this study.

*Pragmatism*

Pragmatism is a research approach that utilises all possible approaches to understand a problem and is often utilised in multi-methods research. Philosophically it is not committed to any selected system of reality, and recognises the benefits of merging diverse approaches to explain the how and what elements of a phenomenon (Creswell 2009). Pragmatism allows the acquisition of knowledge through iterations of independent observations alongside subjective constructions drawn from the values of the researcher when setting out the objectives or drawing conclusions (Plano Clark and Ivankovo 2016).

Given the nature of the objectives in this research, a pragmatic perspective was considered to dually quantify the level of impact on farm level from KT participation and explore the processes that lead to that impact. However, the sequential nature of the quantitative and qualitative analysis and the methodologies utilised a positivist approach was considered

appropriate. Utilising established quantitative methods to estimate the level of impact can be complemented by examining the key factors that drive impact through qualitative interviews.

**Research Approach – Multi-Methods**

The literature on estimating the impact of agricultural KT is typically either quantitative or qualitative analysis based. Quantitative analysis tends to adopt KT participation as an aggregated binary variable on the basis of enrolment and estimated as an explanatory variable on farm outcomes (e.g. Davis et al. 2012; Läpple and Hennessy 2015). These analyses defend their approach on the basis of statistical reliability and the generalisability of the findings. The quantitative analyses of this study also adhere to this approach. However, the heterogeneous motivations and preferences of farmers imply that this impact is likely to vary across observations which limit the quantitative analysis somewhat. In contrast, qualitative analyses can deepen our understanding of the factors that drive KT impact by exploring the nuances associated with each stage of the KT process. However, qualitative analyses are limited in terms of generalisabilty given the inevitable lower sample sizes.

In short, quantitative measures are important and necessary for evaluation but is insufficient to improve understanding of effectiveness unless accompanied by discursive and qualitative insight (Hodge and Midmore 2008). This trade-off in methodological approaches is overcome in this study by utilising both quantitative and qualitative analysis to complement each both forms of analysis. This approach allows for the coordination of different perspectives to fully understand the social phenomena under investigation (Alasuutari et al. 2008). The utilisation of both techniques can bridge the gap left by each mono-method in isolation as the quantitative analysis provides evidence of impact and the qualitative improves our understanding of the mechanism that provides this impact (Faure et al. 2012). This approach offers an outcome-oriented method of inquiry (Johnson and Onwuegbuzie, 2004).

On this basis, multi-methods analysis was chosen as most suitable to address the research questions based on the likelihood to lead to superior findings given the respective limitations of each mono-method (Johnson et al. 2007). The identification of impact alone is insufficient to explain KT related impact without an enhanced understanding of the factors that drive it. In this study the qualitative data provides additional insights to the

quantitative findings to determine the '*what*' and '*how*' elements of knowledge transfer impact on farm level. Nordin and Höjgård (2016) commented that identifying the causal impact of KT participation is one step, but identifying which farm management practice they affect or what aspect of the service make it effective are also pertinent considerations which necessitates qualitative enquiry. Multi-methods research ensures the key research objectives are met effectively.

This research was conducted on a phased basis in line with the sequential exploratory strategy as outlined by Creswell (2009). This approach is characterised by analysis of quantitative data in the first phase which is typically more weighted than the subsequent qualitative data that is collected and analysed to build on these results by providing a narrative on how these results were achieved. This multi-method approach enables this study to address the key research questions on quantifying *what* the level of KT impact as well as explaining *how* this impact was achieved which improves the robustness and validity of this study. Accordingly, the first phase of research focussed on the quantitative analyses with the Teagasc National Farm Survey (NFS) providing a panel data set containing information on farmer behaviour and farm performance related variables. This was supplemented with organisational data derived from internal administrative records relating to adviser numbers and office allocation and both data sets were merged to determine causal relationships. Specifically, the quantitative findings identify the causal effects of extension participation on farm level income and profit margin, as well as the relationships based on existing resources and adviser skill base. However, to rigorously examine the process of knowledge transfer in terms of expertise and skills of the provider and absorptive capacity, learning and application of the recipient required a qualitative angle to ensure the completeness of the findings. The final phase involved collecting qualitative data through semi-structured interviews to determine the underpinning processes that contribute to the outcomes identified in the quantitative results.

*Benefits of Multi-Methods*

Multi-methods analysis draws from the strengths and minimises the weaknesses of both quantitative and qualitative research alone (Johnson and Onwuegbuzie 2004).. The primary strength of this approach is the inclusivity of diverse options on how to appropriately answer particular research questions (Johnson and Onwuegbuzie 2004; Plano Clark and Ivankovo 2016). Quantitative methods are useful in showing trends and generalising findings but lack explanations in the context under influential factors

(Nyanga 2012). Qualitative research may not be generalisable given sample sizes, is more difficult to test hypotheses, a more time consuming and can be prone to influences by the researchers' personal biases and idiosyncrasies (Johnson and Onwuegbuzie 2004). However, qualitative data does enable an exploration of the social dimensions and processes that are beyond the scope of quantitative analyses (Nyanga 2012). Multi-methods approach can lever between both methods to add qualitative understanding to quantitative relationships and provide stronger evidence for findings through the convergence and corroboration of findings (Johnson and Onwuegbuzie 2004). This logic represents the key motivation for employing a multi-methods approach in this study to evaluate the impact of KT on farm level performance.

Mixed methods research was also considered for this study. However, the main criticisms set against mixed methods research are based on the arguments of epistemological commitment neglect and that the paradigms of quantitative and qualitative are fundamentally separate and cannot be combined (Bryman 2008). The epistemological concern is based on the rigidity of the commitments set to both research methods that imply that the outcomes are rooted in opposing conceptual positions inherent to each. For example, quantitative analysis aims to achieve generalisability as opposed to qualitative insight into a narrow aspect of social life. Similarly the concern over the paradigms is based on the incompatibility of both methodologies and that essentially one paradigm is dominant and any attempt at 'mixing' is solely superficial (Bryman 2008; Denzin 2008). The intertwining of these methodologies is key and is based on the assumptions and values underpinning each, as opposed to conducting two separate methodologies in tandem and portraying them as mixed. To overcome this challenge, it is crucial that mixed methods research is robust and justified and not simply multiple strands of a study pieced together. The research design must incorporate the mixed or complementary nature of the study as the failure to do so imply the research is not genuinely mixed methods (Yin 2006). This approach could be considered 'multi-method' research as opposed to 'mixed methods' which relies on incorporating multiple ways of knowing with an emphasis on inclusive findings (Creswell 2016).

On this basis, this study applies multi-methods analysis as the quantitative and qualitative aspects are conducted sequentially as opposed to being integrated. Detailed explanations of each method is provided in each analytical chapter to follow. However, this research does not claim to be the first analysis to utilise a multi-methods approach. Nyanga (2012) provides one such example by employing both quantitative and qualitative methods

approach to the factors affecting conservation agriculture in Zambia, citing the superiority of the combined approach to improve understanding as opposed to a mono-method. The quantitative aspect focused on the econometric relationships established in a survey, followed by qualitative 'digging' into the underlying factors such as trust, quality and extent of knowledge assessed in focus groups. This paper found that combining both datasets informed the findings and policy implications comprehensively. Similarly Prager et al. (2016) employed a multi-methods approach to evaluate the quality of advisory services. They distinguished quality into 'technical quality' which measures actual changes such as their performance, and 'functional quality' which is concerned with the processes of how the service is being delivered. The former was quantitatively measured to address *what* the actual changes within a KT organisation were while qualitative insight was provided to the narrative of *how* knowledge was absorbed and implemented. Quantitative measures related to factors such as the time spent with a client or the frequency of interactions were considered and complemented with qualitative factors such as the importance of trust and preferred methods of learning. A similar approach is appropriate for this study.

These examples highlight the value in employing a multi-methods approach and were chosen on the basis of their suitability in addressing the research questions. The quantitative analysis estimates the level of impact from KT participation and the qualitative expands on how this impact is achieved. This approach ensures a robust investigation which can be used to inform future policy decisions. The phases of analysis, both quantitative and qualitative, are described in more depth in subsequent sections, but first an overview of the data is provided.

**Data Overview**

Two quantitative data sources were utilised for this research, namely the Teagasc National Farm Survey (NFS) panel data set which contained data on farm level performance and administrative data which contained data on KT resources. These were complemented by qualitative data collected through semi-structured interviews with key informants in the KT process. Detailed descriptions of each dataset and the key variables analysed are provided in the analytical chapters, with a brief overview presented below.

*Teagasc National Farm Survey*

The Teagasc NFS is a vital source of data to inform KT programmes and agricultural policies more generally (Miley 2008). The NFS is an annual survey collected in Ireland since the early 1970s in line with obligations to the Farm Accountancy Data Network (FADN) required by the European Union (EU) (Green and O'Donoghue 2013). It is a panel data set of approximately 1,100 farms nationwide in Ireland per annum which are weighted to represent the majority of the farming population. However, from 2012 the collection method was revised to exclude the smallest farms and the more recent sample collects approximately 900 farms to represent approximately 80,000 farms in Ireland (Läpple and Hennessy 2015). The panel is unbalanced in the sense that farms do not remain permanently in the sample and may be dropped permanently or temporarily before re-entering the sample (Hynes and Garvey 2009). Data is collected in a series of face to face interviews by a professional team of recorders (Läpple and Hennessy, 2015) which ensures its accuracy and consistency.

The survey assembles a rich data source relating to farm output, costs and revenue, as well as collecting variables on KT participation which is crucial for this study. The data is collected on the basis of six different farming systems, namely dairy, cattle rearing, cattle other, mainly sheep, tillage and mixed livestock (Läpple and Hennessy, 2015) which are broken down by region, soil type, farmer characteristics and scale. The panel data format enables the tracking of farms over time which allows an evaluation of KT impact over time with some authors suggesting initial benefits may deteriorate over time (Anderson and Feder, 2004), or benefits can perpetually increase (Läpple and Hennessy, 2015). This provides a valuable resource to conduct the quantitative analysis.

*Administrative Data*

The Teagasc NFS was supplemented with data on Teagasc resources for the second quantitative analysis. Specifically, the characteristics of extension offices were assembled including the locations and number of advisers and clients assigned to each office. This data was collected from administrative records and staff handbooks to ensure a comprehensive portrayal of KT resources over the period of economic recession from 2008 to 2014. This enabled the tracking of the organisational consolidation caused by economic constraints from the recession (Cawley and Boyle 2011). This resulted in a number of extension office closures and a significant reduction in the number of advisers

due to retirements and the introduction of an employment moratorium. As a consequence, KT services were more centralised, average distances to local farms increased and the ratio of clients to advisers rose sharply over the period. The implications of this consolidation created additional challenges for KT provision and the second quantitative analysis focuses on this aspect when evaluating the impact of KT on farm level profitability over this period.

*Qualitative Data*

The qualitative data was collected through a series of semi-structured interviews with purposively selected informants on both the adviser and farmer side. These participants were selected based on their relevance to the research question, namely their likely involvement in impactful KT interactions. Data was collected on a face-to-face basis which allowed participants to elicit and develop insights on their historical recollections (Creswell 2009). This also enabled the interviewer to probe an issue as it arose from the replies which added flexibility to the process and provided additional insight into the thought process of the interviewee (Bryman 2008). Interviews were digitally recorded and transcribed verbatim by the interviewer, before being coded for analysis. In total 10 interviews were conducted after initial piloting which is in line with similar studies related to farming and reached data saturation (Morris et al. 2017). This approach yielded a rich data set that enabled the study to address the qualitative research question.

**Quantitative Analysis**

The initial research question sought to quantitatively measure the impact of KT on farm level income, to estimate the value of participation for farmers over the period 2000 to 2013. This type of analysis is complex as the motivations to participate can vary significantly in an inherently heterogeneous agricultural sector. Birkhaeuser et al. (1991) identified a number of issues when evaluating the impact of extension services including the influence of policy and market environments as well as the information flow, personal preferences and ambitions. However, an endemic challenge to these quantitative evaluations is that of statistical endogeneity brought about by confounding factors affecting the variable of interest, which causes a bias in the estimation. An endogenous explanatory variable exists when the variable is correlated with the error term (Wooldridge 2013). Failure to control for this issue can lead to inaccurate claims on the validity of findings (Abdallah et al. 2015).

Endogeneity has three primary causes. Firstly, omitted variable bias causes a problem for analysis as farmer characteristics such as their innate ability, effort, ambition or motivation are likely to affect their farm performance, yet this data is unobserved. Secondly, self-selection bias is a methodological error caused by initial differences between participants and non-participants due to the conscious decision to enrol in an extension programme or not (Imbens and Wooldridge 2009; Nordin and Höjgård 2016). Läpple et al. (2013) explained that higher skilled producers may be more likely to participate in KT services, yet we do not have a variable to reflect this issue. Conversely, farmers with higher ability may not deem extension services necessary given their own capabilities on the farm. On the other hand, farmers with lower ability may seek to participate in KT to bolster their performance, or alternatively they may feel participation is not worthwhile. Akobundu et al. (2004) suggested that extension programmes themselves may purposively target specific farmers whether disadvantaged or eager to participate. This may be due to attempting to improve the performance of vulnerable producers in the first instance, who may avoid such opportunities without adequate incentives. Conversely, advisers may be more likely to target more motivated participants or those recognised as peers to diffuse knowledge and information further (Genius et al. 2013; Läpple et al. 2013). Conversely, advisers may avoid particular clients for various reasons such as location, personal characteristics or due to time constraints. In short, farmers participating in KT services may be systematically different than those who do not (Hennessy and Heanue 2012; Tamini 2011). Finally, another form of bias may be related to measurement error. As KT participation is typically measured as a binary variable for participants versus non-participants it is imperfectly measured and likely to cause a downward (attenuation) bias on the initial regression results without appropriate instrumentation (Card 1999). Accordingly, it is important to note that the direction of the bias is unclear, but the challenge is to correct for this bias which is addressed in the first quantitative analysis through instrumental variable (IV) estimation.

*Instrumental Variable Regression*

There are a number of approaches to deal with endogeneity but the IV approach is efficient as it accounts for multiple forms of bias discussed above provided suitable instruments are identified. The chosen instrument must be correlated with the endogenous explanatory variable (relevant), but uncorrelated with the dependent variable and error term (valid) (Burgess et al. 2016; Murray 2006). If such an instrument can be found, then an unbiased consistent coefficient for the endogenous variable can be estimated (Gujarati

2003). The process involves a two stage least squares regression (2SLS), where firstly the instrument(s) are regressed on the endogenous variable, and subsequently the predicted value of the variable is inserted into the main structural equation and estimated.

Accordingly, the primary challenge for IV analysis is to identify a suitable instrument. Murray (2006) noted that having at least as many instruments as endogenous variables is a necessary condition for identification. For this analysis two instruments were identified to combat the endogenous variable. The distance to the local Teagasc advisory office and a policy change were chosen on the basis of previous literature. Geographic proximity to school was used by Card (1993) and Callan and Harmon (1999) and Heanue and O'Donoghue (2014) used a policy change as an exogenous shock. Both instruments were expected to affect the decision to participate in KT services independently of farmer personal characteristics and/or farm performance. These instruments were also interacted to examine the impact of both combined and improve the estimation approach. The rationale for the instruments is explained in more detail in Chapter 4.

*Random Effects Model*

The second phase of the quantitative analysis focused on the period 2008 to 2014 to evaluate the impact of KT on farm level profitability during a period of restricted resources due to the economic recession of the time. However, this time period removed the option of utilising the policy change instrumental variable of the first analysis. The distance to office was trialled but ultimately too weak and no other suitable instruments were found, which meant an alternative estimation approach was required. The random effects model was preferred on the basis of two selected criteria. Firstly, random effects models enable the individual component associated with heterogeneity of each observation to be absorbed through the error term (Kilcline et al. 2014), which offers a potential solution to endogeneity concerns. Second, although a Hausman test suggested a fixed effects model for this analysis, the lack of variation across years in terms of fixed variables such as farm system and nearest office causes many observations to drop out of the model. On this basis random effects estimation was carried out as the most suitable alternative to the IV regression. The model is explained in more detail and specified in Chapter 5.

## Qualitative Analysis

The qualitative analysis aimed to explore the underpinning processes that drive KT in terms of impact as outlined above. Qualitative data sets are typically drawn from fewer sources than in quantitative studies but they generate richer more detailed information from each of those sources (Levitt et al. 2018). This data was collected through semi-structured interviews with key informants on both the adviser and farmer side to explain the KT process.

### *Semi-Structured Interviews*

Qualitative interviews are a common research technique widely applied in social research and offer the opportunity for additional depth and understanding around a particular topic (Patton 2002). Although a more costly, time consuming and typically reliant on smaller sample sizes, the data collected provides more detailed information than quantitative data collection methods such as surveys. On this basis, semi-structured interviews were chosen to explore the process of KT and how impact is achieved.

The interview schedule was developed on the basis of both theoretical gaps in the literature as discussed in Chapter 2 as well as to enhance our understanding of the quantitative relationships estimated in Chapters 4 and 5. The semi-structured format of the interview questions was chosen on the basis of guiding participant responses whilst also leaving space for elaboration. This ensured a depth of information was collected and allowed for unexpected comments and insight. Advisers were questioned on their perspective of the impact of KT and farmers were questioned as to theirs. Specifically, both were asked as to their roles in each KT activity whether individual or group based, and KT content related to grassland, breeding and financial management were used to direct responses. Both sets of data were then merged to conduct the analysis from the viewpoint of both the knowledge provider and recipient to gain an enhanced understanding of the processes of knowledge being transferred.

Purposive sampling techniques were taken in order to ensure that advisers and farmers who participate in the most impactful KT were identified, namely those located in more profitable regions. All advisers and farmers were involved in Teagasc KT for a minimum of ten years to probe their experiences of the evolution of the KT service. This method of sampling was chosen because the informants were deemed particularly suitable for providing insights into the underlying factors that lead to impact (Eisenhardt and

Graebner 2007). Although this approach could lead to a form of bias by not representing the majority of Irish farmers, it is a pertinent choice to ensure that the factors that drive KT impact are explained, and therefore participants were targeted where impact is most pronounced. This purposive sampling approach is strategic in that it draws on insights from sources that are most relevant to the research question (Bryman 2008; Bryman 2012; Creswell 2009). The knowledge and expertise of the respondents based on their respective experiences of KT over the period in question is deemed appropriate to provide in-depth explanations of the factors that drove impact (Sarantakos 2013). Theoretical coding was undertaken following the Lichtman (2013) stepped approach where codes are refined into categories and finally discussed as concepts. The methodology is explain in more depth in Chapter 6.

## Principles of Research

In line with the methodology outlined above, it is important to address the key principles of research that affect the research methodology. Each one is described in turn, and how they apply to this particular study.

### *Reliability*

Reliability refers to the consistency and reproducibility of findings (Plano Clark & Ivankovo 2016). More common to quantitative analysis the results must be stable and replicable to ensure reliability (Bryman 2008). Reliability was a key principle of this research and has been upheld for both the quantitative and qualitative aspects through rigorous documentation of the data, the sampling procedure and the analyses. The panel nature of the Teagasc NFS data set and model specifications ensure an alternative researcher would arrive at the same estimates using this approach. Concurrently, the interview schedule outlined a set list of questions for each participant with unprompted room for expansion if they so desired. The methodology is documented in detail in Chapter 6 to ensure a clear pathway of analysis is provided. These methods ensure reliability in both data sets in this study.

*Validity*

Ensuring that claims inferred from findings are valid is a key aspect of conducting research. It is imperative that any conclusions drawn from a set of results are accurate and demonstrate integrity to fulfil validity criteria (Bryman 2008; Plano Clark & Ivankovo 2016). Validity refers to the quality of measurement approaches in terms of their precision, accuracy and relevance in producing findings that are in agreement with theoretical and conceptual values (Sarantakos 2013). Furthermore, validity can be either 'internal' meaning that the researcher must have the ability to draw correct inferences from the data or 'external' where the results can be generalised to a larger population (Plano Clark & Ivankovo 2016). The inference of causal relationships and the generalisability of results are questions of validity (Bryman 2008). This study adopts a multiple-method approach to enhance the validity of the analysis to achieve superior outcomes relative to a mono-method approach solely (Fielding and Fielding 2008). The quantitative phase of this study draws from the Teagasc NFS as outlined above, which is a representative panel data set frequently employed for agricultural economic analysis. The qualitative data is collected on a semi structured basis where participants have ample scope to elaborate or not as they wish, but critically is collected on a consistent and stable format for all participants. This ensures the quality of the data and the results is accurate and in line with the theoretical model adapted from the literature (Creswell and Plano Clark 2007).

*Objectivity*

Typically associated with positivist research, the principle of objectivity refers excluding the values of the researcher when conducting analysis (Bryman 2008). A researcher risks introducing bias to the analysis if their personal opinions persuade a specific view on an issue. This 'independence' of the researcher is key and it is imperative that the social reality is presented as it is rather than interpreted by the researcher (Sarantakos 2005). The quantitative analyses in this study are all inferred from the data so objectivity is not an issue. The qualitative analysis documents the method of analysis to present how themes were refined and categorised in line with Lichtman's (2013) approach. The presentation of the analysis in this format ensures that objectivity is not an issue in this study.

*Representativeness*

The representativeness of analysis is commonly applied in quantitative studies as sample sizes and statistical techniques are executed to generalise a particular finding (Sarantakos 2005). This is an advantage of the Teagasc NFS which was utilised for the quantitative analyses. However, the data set does have certain limitations such as the omission of the smaller farms in the sample, and the failure to capture private based KT clients. The representativeness of qualitative analysis is more challenging but can be overcome by increasing observations, purposively searching for contrasting cases or to create a convincing argument for the randomness of the participants chosen (Miles and Huberman 1994).The qualitative analysis in this study is limited in terms of representativeness of the participants who were purposively selected based on their relevance to the research questions as opposed to prioritising representativeness. This presents a limitation, but was viewed as worthwhile to focus on participants involved in the most impactful KT to explain the drivers of impact.

**Conclusion**

In order to fully address the research objectives of this study a multi-methods approach was chosen as most appropriate to answer both *what* the level of impact was and *how* this impact was achieved. This study utilises both quantitative and qualitative techniques to gain an enhanced understanding of the phenomenon being studied, in this case the impact of KT on farm level performance. Therefore a positivist perspective is taken that is most suitable to address the research questions, as well as taking advantage of the data sets and maintains the principles of research as outlined above.

The analyses are undertaken on a phased basis with the initial contributions being quantitative in nature followed by further exploration through qualitative insight. The quantitative analyses was structured according to the formats of the two journals where each was published. Accordingly, the formatting differs in each analyses with additional tables of results annexed for Chapter 4 which was published in *Applied Economic Perspectives and Policy*. Chapter 5 was accepted for publication in *The Journal of Agricultural Education and Extension* which includes the full analysis within the chapter. These structures also inevitably involve a certain level of repetition, particularly around the context and rationale for each analysis. In contrast, the qualitative analysis is structured as an overarching analysis that will be subsequently formatted to fit the

requirements for a journal submission. These analyses are the focus of the next three chapters.

# Chapter 4 - Quantitative Analysis I: The Impact of Extension Services on Farm Level Outcomes: An Instrumental Variable Approach[1]

## Introduction

Knowledge transfer (KT) activities delivered through agricultural extension organisations can be used to build the capabilities of clients, through improved problem solving, decision making and management (Vanclay and Leach 2011). It is a means of transferring specialist knowledge from research or public policy to farm level, commonly adopted worldwide as noted previously. Most developed countries have a form of public extension service for rural land managers funded largely through general taxation (Garforth et al. 2003). Governments actively promote extension services as a means of knowledge diffusion and technology adoption as well as to develop innovative solutions to emerging challenges (Läpple and Hennessy 2015). This form of public extension has since been supplemented by the private sector with the commonly shared objective of improving the performance of farms. These KT activities help to change farmer behaviour to achieve desired policy goals such as set targets to the sector such as Food Wise 2025 targets in Ireland, but are coupled with a financial responsibility with a renewed emphasis for 'value for money' from public policies. Extension services can act as policy leavers to change existing behaviour, but must also represent a worthy investment for policy makers. Furthermore, participating farmers must also experience a value for money return given the fee level paid, particularly given existing income challenges caused by economic volatility, and a strong reliance on subsidy payments (O'Donoghue and Hennessy 2015). Therefore, estimating the impact of KT participation on farm income is prudent and ensures a common outcome is measured regardless of the type of KT activity employed. In order to achieve this it is imperative that the estimation is robust and unbiased, as multiple confounding factors can influence this impact. In this chapter this obstacle is overcome by instrumenting the extension variable to remove these influences.

Many studies show that interaction with extension services positively affect farmer's technology adoption decisions and profitability levels. For example Kilpatrick (1996) argued that farmers who engage with extension were more likely to implement changes on their farm to improve long term profitability. Owens et al. (2003) found a positive

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relationship between extension and the value of crop production of approximately 15 per cent higher. Similarly, Garforth et al. (2003) found participatory extension positively affected both technology adoption and profitability. This chapter focusses on the latter by examining the relationship between extension engagement and farm income, which has been the subject of other studies. For example, Dercon et al. (2009) found a positive impact for extension engagement on poverty alleviation in Ehiopia by reducing headcount poverty by 9.8% and increasing consumer expenditure by 7.1%. Davis et al. (2012) found that participation in farmer field schools increased farm income by 61% in East Africa. In an Irish context limited research has been conducted on the impact of public extension services. Läpple et al. (2013) found a positive relationship between dairy discussion group membership and gross margins. Moreover, the role of incentives (Läpple and Hennessy, 2015), agricultural education (Heanue and O'Donoghue, 2014), technology adoption (Hennessy and Heanue, 2012), and the role of advisers in facilitating participatory approaches (Farell et al. 2008, Mahon et al. 2010) have been examined, yielding mixed results.

Whilst positive results are common, this is not always the case and each result must be treated with caution given econometric challenges (Anderson and Feder 2004). Indeed the inconsistency in research findings could be partly due to the broad range of KT methods and disparate outcome measures (Läpple and Hennessy 2015), and therefore, designing evaluation methods is a major challenge (Ragasa et al. 2016). However, from a policy perspective the impact of KT services is the ultimate criterion (Birner et al. 2009), and thus is the key objective of this study to provide a robust causal estimation of the impact of KT participation on farm income. Providing an accurate and valid estimation of impact can assist the policy formulation process as policymakers can rely on the likely impact of an initiative with greater precision. In order to achieve this, it is critically important that the estimation addresses econometric concerns related to the issue of endogeneity.

The econometric issue of endogeneity is typically caused by omitted variable bias, measurement error and self-selection biases. Failure to combat endogeneity may lead to incorrect inferences on the causal relationship between KT participation and farm level income (Abdallah et al. 2015; Akobundu et al. 2004). The omission of variables such as innate ability of participants as an explanatory variable could overestimate the true effect of extension on farm income. Conversely, measurement error is likely to underestimate or overestimate the true effect of the relationship (Card 1999). Similarly, self-selection

biases are implicit in this research with the motivation to engage with KT being a critical element of estimating impact (Nordin and Höjgård 2016). For example, more capable farmers may be more motivated to engage with extension services to augment their performance, whereas weaker farmers may be less likely to participate. This chapter aims to overcome this challenge by combating the endogeneity through instrumental variable (IV) regression.

The IV approach is dependent on identifying suitable instruments that affects the endogenous variable in question which is the relevance condition, but do not impact directly on the dependent variable which determines validity. Card (1999) argued that to present a convincing analysis of the causal link between such variables requires an exogenous source of variation in the endogenous variable, in our case the decision to participate in extension services. Identifying a suitable instrument (a variable that is correlated with the decision to engage with extension services, but not directly related to the dependent variable of farm income) is the key challenge. These instruments 'purge' the endogenous regressors, and allow consistent coefficient estimates (Gabel and Scheve 2007). In our case, such an instrument must affect the decision to participate in extension services (relevant), but not impact farm family income directly (valid). Distance from the local advisory office and the introduction of a policy change in 2005 are chosen as appropriate instruments to meet these conditions. The former is expected to negatively affect the decision to participate but uncorrelated with farm income, whereas the latter is expected to incentivise participation for assistance with subsidy applications decoupled from current production based on historical receipts. These instruments enable the evaluation of the impact of extension on farm level income in Ireland over the period 2000-2013.

The remainder of the chapter is structured as follows: initially the context for extension services in Ireland is outlined, followed by a review of the relevant literature. Next there is an overview of the methodology and data is provided. Finally the results are discussed and the conclusion outlines the policy implications along with some limitations and recommendations for further research.

**Context**

In order to conduct the analysis, it is important to outline the context in which this research is addressed. Agricultural extension incorporates varied KT activities to advise farmers on diverse objectives. Extension providers can be viewed as risk management devices from policy makers to mitigate issues in the rural economy, or as drivers of growth at farm level to ensure best practices are followed systematically. Extension providers also assist farmers to overcome barriers to achieving goals due to a lack of knowledge, motivation, resources, insight and power or a combination of all of these (Van den Ban and Hawkins 1988). The public extension provider in Ireland, Teagasc, aims to assist farmers on core issues such as productivity, food safety, and the environment among others (Boyle 2008).

The extension service in Irish agriculture is led by both public and private consultants, with clients split relatively evenly among both types. Prager et al. (2016) estimated that approximately 250 private advisers (mainly represented by the Agricultural Consultants Association) were in operation alongside 250 public advisers employed by Teagasc. Miley (2008) noted that public advisory offices were established in Ireland in 1980 (under the ACOT agricultural bill), and were subsequently merged with the national agricultural research institute (An Foras Talúntais) to form Teagasc. Teagasc is the main body for the public delivery of agricultural research, advice and training since 1988. It is a unique organisation that combines research, extension services, and education (Prager et al. 2016), and 30% of the operating budget of approximately €160 million is directed towards extension programmes (Teagasc 2016). The inclusion of research and extension in the same organisation is a key advantage as research is a prerequisite for improving farm performance (Van den Ban and Hawkins 1988). More recently Teagasc has become partially funded by charging a fee for services to clients as noted above. However, it is still classified as a semi-public organisation that receives significant funding from the Irish government. Läpple and Hennessy (2015) noted this has a restriction on increasing participation, as opposed to rewarding farmers for participation through financial incentives. However, they also found that those that 'self-selected' into extension programmes received increased benefits than those who participated to avail of the financial incentive offered. Similarly, Hu et al. (2009) analysed this partial funded system in China and found that priorities changed for extension agents if they needed to secure their own incomes through commercial activities.

The research reported here refers to Teagasc clients only for two reasons. Firstly, the level of public expenditure allocated to the public extension provider, and secondly, data constraints related to private extension providers and their clients. Indeed, as the majority of private extension providers in Ireland consist of just 1-3 advisers (Prager et al. 2016), that data is more likely to be fragmented as opposed to the superior data available from Teagasc extension. For this reason, farmers who participate in private KT related activities are not captured in this study. Teagasc clients include any farmer who participates in any KT activity under the various contracts on offer whether a basic contract that involves scheme assistance only or a more intensive contract that includes discussion group membership and on farm consultations.

**Literature Review**

There are several examples of impact evaluations relating to KT services, with varied results across diverse contexts (Anderson and Feder 2004). Given the pluralistic objectives of extension providers and the diversity in outcomes and methodological options, this variability and inconsistency is not surprising (Läpple and Hennessy 2015). This section highlights the most relevant literature to situate the research question and clarify the contribution.

Previous studies have attempted to quantify the impact of knowledge transfer activities in agriculture. Griliches (1964) conducted some of the earliest research and found evidence of a positive relationship between extension participation and farm productivity, as well as highlighting the importance of education for the farm labour force. Marsh et al. (2004) conducted a crop based case study in Western Australia, and found that extension services increased farmer adoption of the crop, and found a net economic benefit for utilising extension agencies. Similarly, analysis of the impact of one-to-one consultations and productivity showed a positive relationship (Owens et al. 2003; Wang 2014), but another case found this benefit diminished over time (Krishnan and Patnam 2014). Participatory KT methods have also shown a positive outcome for farm yields in terms of crop output (Davis et al. 2012) and milk yield (Läpple and Hennessy 2015). In contrast, Hunt et al. (2014) found the impact of KT on productivity declined over time due to capacity constraints. This reflects the significant variability in results (Anderson and Feder 2004).

Specifically in relation to extension participation and financial returns there are recent studies on participatory extension programmes impact in terms of increased gross margin per hectare of €310 in the Irish dairy sector (Läpple et al. 2013), and an increase of €150 gross margin per dairy cow also in Ireland (Läpple and Hennessy 2015). The former study employed an endogenous switching model whereas the latter utilised propensity score matching methods to address endogeneity using panel data sets. Davis et al. (2012) also found a positive effect using the propensity score matching method identifying income gains of 21-104 per cent in selected African nations. These studies adopt extension participation as a binary variable based on participation. The switching model method relies on conditional expectations of impact based on non-participation in the extension programme compared with the actual results. The main advantage of the switching model is that it combats self-selection biases but it is based on the hypothetical case of an outcome. The propensity score matching approach is effective but relies on a number of decisive steps based on the quality of data and underpinning assumptions often involving a trade-off between bias and efficiency (Caliendo and Kopeinig 2008).

These studies utilised various econometric methodologies but endogeneity concerns were not necessarily central to the analysis and they did not employ the IV approach, which may lead to incorrect inferences due to uncontrolled biases that remain (Abdallah et al. 2015; Akobundu et al. 2004). Indeed whereas some studies may prioritise a particular form of bias to control, the IV approach combats multiple forms of endogenous biases (Card 1999; Cawley and Meyerhoefer 2012; Howley et al. 2015). Thus, the IV approach is superior in that it removes the need to prioritise specific types of bias over others, but combating all forms ensuring an improved estimation of extension impact on farms. IV estimation can consistently estimate coefficients that will almost certainly be close to the true coefficient value if the sample size is sufficiently large (Murray 2006). However, this approach is dependent on the precondition of identifying appropriate instruments, which often proves challenging.

Accordingly studies on the impact of extension participation on farm level income using an IV approach are less common but there are exceptions. Nordin and Höjgård (2016) applied an IV methodology to evaluate extension services in Sweden and found both a societal and farm level benefit to participation in relation to nutrient management. The mean number of adviser visits to a farm was adopted as an instrument for the actual number of visits to a specific farm based on a positive relationship between the agent expertise and farm type. They found that OLS estimates underestimated the benefits of

the extension programme compared to the corrected IV estimates. Akobundu et al. (2004) utilised this approach and found a US extension programme that incorporated both one-to-one and group based activities increased net farm income, but the level of return relied on the intensity of participation. They utilised the distance to local extension office, the intensity of participation captured through the number of adviser on-farm visits, and the level of household debt with higher debts classified as more likely to increase adviser visits, as suitable instruments. Similarly, Heanue and O'Donoghue (2014) found positive economic outcomes for farmers who participated in agricultural education in terms of farm income and the internal rate of return to investment also using an IV approach. As instruments they used the distance to local agricultural college and the introduction of a policy change. This study follows on from that work but instead focuses solely on Teagasc extension clients.

Whilst an IV approach is not common in the agricultural economics literature it is important to note it is widely used in other fields with significant policy implications. For example, it has been utilised to study the impact of economic shocks on conflict where adverse weather conditions instrumented economic activity and showed an increase in the probability of civil conflict in the following year (Miguel et al. 2004). IV estimation is also viewed as a sensible addition to the analytical toolbox in health economics (Rassen et al. 2009). Indeed, in one such study regional cardiac catheterisation rates were adopted as instruments to explore the relationship between specific treatments and mortality rates with a 16 per cent survival benefit reported (Stukel et al. 2007). Similarly, genetic variation in weight was applied as an instrument in a study on the relationship between obesity and medical costs which found that previous literature had underestimated these costs (Cawley and Meyerhoefer 2012). IV estimation has also been applied to examine the relationship between education and subsequent income earnings with distance to college used as an instrument and also found a previous underestimation in the literature (Card 1999). Therefore, the literature presents examples of downward biases that are subsequently corrected through instrumentation and this research queries whether this is also the case for the impact of extension on farm level income. If so, existing estimations of impact may have underestimated the true effect on farms and the effectiveness of extension services to act as policy instruments could be more pronounced.

Accordingly, the purpose of this research is to measure the impact of extension programmes on farm incomes. The IV approach ensures endogeneity concerns are addressed leading to a robust estimation of impact given the identification of suitable

instruments. In this study it is assumed that farmers utilise extension programmes primarily to improve profitability. Other beneficial outcomes are taken as secondary. Clients of extension programmes are expected to achieve higher average farm income levels than farmers who do not use extension programmes. Thus, a positive relationship is expected.

**Methodology**

Birkhaeuser et al. (1991) identified a number of problems associated with assessing the impact of extension activities such as the phase of the farmers' development cycle, policy and market influences and information flows, but the predominant issue is that of endogeneity. An endogenous explanatory variable exists when the variable is correlated with the error term (Wooldridge 2013). This means that the estimated coefficient for that variable will be inconsistent and biased as its magnitude is somewhat determined by the error term. This may lead to inaccurate interpretations of the effects of findings unless appropriate action is undertaken (Abdallah et al. 2015).

Endogeneity has three primary causes. Firstly, omitted variable bias causes an obvious problem for analysis as a farmer's innate ability, effort, ambition or their motivation would have an effect on the impact of extension engagement, yet this data is unobserved. Secondly, self-selection bias is a methodological error caused by initial differences between participants and non-participants due to the conscious decision to enrol in an extension programme or not (Imbens and Wooldridge 2009; Nordin and Höjgård 2016). Läpple et al. (2013) explain that higher skilled producers may be more likely to adopt extension services given their capacity and motivation to enhance their enterprise, yet we do not have a variable to reflect this issue. Conversely, farmers with higher ability may not deem extension services necessary given their own capabilities on the farm. Similarly farmers with lower ability may seek advisory assistance to bolster their performance, or alternatively they may feel investing in advisory services is not worthwhile. Akobundu et al. (2004) suggested that extension organisations themselves may purposively target specific farmers whether disadvantaged or eager to participate. This may be due to attempting to improve the performance of vulnerable producers in the first instance, who may avoid such opportunities without adequate incentives. Conversely in the latter example, advisers may be more likely to target more motivated participants who may be more likely to disseminate the knowledge (Läpple et al. 2013). Conversely, advisers may avoid particular clients for various reasons such as location, personal characteristics or

due to time constraints. This indicates a bidirectional causality with regard to self-selection bases. Therefore, farmers using the extension service are systematically different than those who do not (Tamini, 2011; Hennessy and Heanue 2012). Finally, another form of bias may be related to measurement error. Given the endogenous variable for extension participation is imperfectly measured as a binary variable in our analysis, this is likely to cause a downward (attenuation) bias on the initial Ordinary Least Squares (OLS) estimation prior to instrumentation (Card 1999). The variety of extension programmes options on offer range from annual visits to assist with scheme assistance to intensive technical assistance packages involving on-site visits, discussion groups and seminars. The utilisation of participation as a binary variable removes this variability for the purpose of providing an aggregated impact estimation regardless of the type of extension adopted, hence it is imperfect but necessary for this analysis. Accordingly, it is important to note that the direction of the bias is not necessarily upward, given intuitive expectations on omitted ability or self-selection.

There are a number of approaches to deal with endogeneity as discussed in the previous section. However, the IV approach is efficient as it accounts for multiple forms of bias listed above provided suitable instruments are identified. The instrument must be correlated with the endogenous explanatory variable (relevant), but uncorrelated with the dependent variable and error term (valid) (Burgess et al. 2016; Murray 2006). If such an instrument can be found, then an unbiased consistent coefficient for the endogenous variable can be estimated (Gujarati 2003). The process involves a two stage least squares regression, where firstly the instruments are regressed on the endogenous variable, and subsequently the predicted value of the now exogenous variable is inserted into the main structural equation and estimated.

Accordingly, the primary challenge for IV analysis is identifying a suitable instrument. Murray (2006) noted that having at least as many instruments as endogenous variables is a necessary condition for identification and in most cases is sufficient. On this basis two instruments were identified and subsequently both were interacted to combat the endogenous variable. The distance to the local extension office and a policy change effect were chosen on the basis of previous literature. Geographic proximity was employed by Card (1993) and Callan and Harmon (1999) along with Heanue and O'Donoghue (2014) where the latter two also used a policy change as an exogenous shock. Callan and Harmon utilised the introduction of free schooling and Heanue and O'Donoghue adopted the introduction of the Stamp Duty Exemption Scheme that targeted young trained farmers

as instruments. In both examples the argued the instrument incentivised participation in education and agricultural training respectively, but did not affect income levels directly. Both instruments were expected to affect the decision to participate in extension services independently of farmer personal characteristics and/or farm performance. These instruments were also interacted to examine the impact of both combined and improve the estimation approach. The rationale for the instruments is explained in more detail in the subsequent section.

As noted above a 2 Stage Least Squares (2SLS) IV approach is applied. Thus our initial stage is to test for the exclusion restrictions of the instruments (Wooldridge 2013). In other words, we apply the first stage which is the reduced form equation for our endogenous regressor through the following reduced form equation for $y_2$:

$$y_2 = \pi_0 + \pi_1 z_1 + \pi_2 z_2 + \pi_3 z_1 z_2 + \boldsymbol{\pi}\boldsymbol{X} + v_2 \quad (1)$$

where $y_2$ is our endogenous regressor (extension participation), $\pi_j$ is our estimated parameter coefficients, $z_k$ are our instruments, $\boldsymbol{X}$ is a vector of all other explanatory variables and $v_2$ is our error term. Partial correlation at least between $z_k$ and $y_2$ is necessary to fulfil the requirement that the instruments affect the endogenous regressor.

Therefore we can apply our second stage and specify our structural equation as follows:

$$y_1 = \beta_0 + \beta_1 \hat{y}_2 + \boldsymbol{\beta}\boldsymbol{X} + u_1 \quad (2)$$

where $y_1$is the dependent variable of family farm income, $\beta_j$ is our estimated parameter coefficients, $\hat{y}_2$is our 'purged' variable of interest namely, participation in extension services, $\boldsymbol{X}$ is the same vector of all other explanatory variables as in the initial stage and $u_1$ is our error term.

All models are presented with selected specification tests in the results. In the first stage, the multivariate Cragg-Donald Wald F test was conducted measuring whether the instruments affect the endogenous variable. Stock et al. (2002) outlined a rule of thumb that the F statistic must exceed 10 to avoid instruments being classified as weak. For the IV models the Sargan statistic is reported which measures the null hypotheses that all instruments are valid. This is recognised as the standard overidentification test of the validity of the instruments and is a benefit of the 2SLS approach (Howley et al. 2015). Cawley and Meyerhoefer (2012) noted that rejecting the null hypothesis of no effect is

impossible and therefore doubt will remain if an instrument is truly exogenous. However, the Sargan test of validity is applied on occasion and failure to reject implies the instruments cannot be argued as invalid, which bolsters the argument of their validity as instruments. If the computed chi-square exceeds the critical chi-square value, we reject the null hypothesis, which means at least one instrument is correlated with the error and therefore invalid (Gujarati 2003).

**Data**

Specific data was required to conduct this analysis. Firstly, it was important to observe participants and non-participants in extension programmes. This was the basis of our endogenous variable. A binary variable was established based on extension participation with Teagasc coded with a value of 1 for clients and 0 otherwise. Thus, non-participants were identified as all observations that are not recorded as Teagasc clients. While this binary variable is imperfect in the sense of not differentiating between types of engagement as noted previously, it does provide an initial aggregated value of extension participation that is testable which is a common approach in the literature. Teagasc clients include annual contract holders as well as those that use the service for scheme assistance, defined as participation solely for the purpose of fulfilling bureaucratic requirements to receive subsidy payments as opposed to technical advice. Annual contracts involve 'packages' of services that include combinations of events, discussion groups, farm walks, consultations and news. Farm family income, which includes subsidies, was used as the dependent variable as it provides a useful barometer of performance, particularly over time and reflects the total income accrued to the household related to farm-based activities. In addition, this measure also captures the effect of extension participation regardless of which type of service was adopted. Furthermore, additional factors that influence farm income, such as the geographic location, farm system and other characteristics were also included. These data were derived from the Teagasc National Farm Survey (NFS).

The Teagasc NFS is an annual panel data source collected as part of the Farm Accountancy Data Network (FADN) required by the European Union. It consists of approximately 1,100 farms per annum representing approximately 110,000 farms of the population in Ireland (Läpple and Hennessy 2015). This dataset determines the financial situation on Irish farms by measuring the level of gross output, margins, costs, income, investment and indebtedness across the spectrum of farming systems, sizes and profiles

in the various regions (Connolly et al. 2010). Panel data allows the tracking of the same farms over time which enriches analysis of this type as some farms may opt in, opt out, avoid, return or engage constantly with extension services.

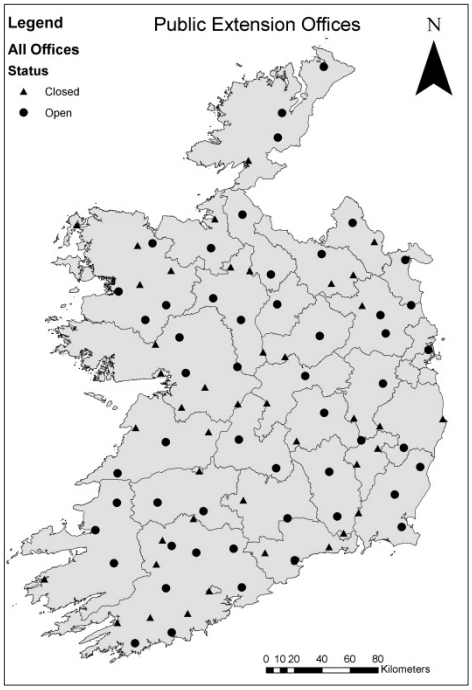
For the purpose of this analysis, and given that the introduction of the Single Farm Payment policy change in 2005 was chosen as an instrument, the sample selected prioritised farms that were in the sample prior to this period, but only became Teagasc clients subsequently. This refines the sample, and exploits a natural experiment by ensuring we focus on a similar group of farmers who were likely to have been motivated to become clients in response to the policy change. Including the full sample increases the variation in the results due to the inclusion of 'self-selecting' farmers who may have participated into extension services for reasons outlined above regardless of the policy change (Läpple and Hennessy 2015). Each observation employed an average population weight recorded on the NFS over the period to ensure the sample was representative of the general farming population (Buckley et al. 2016). Accordingly, the final sample size is 8,951 observations over the years 2000-2013 inclusive for the models estimated. The estimated coefficients are therefore an average estimation across the 14 years of the analysis.

The dependent variable was family farm income, which was divided by utilisable agricultural hectares to obtain a more representative indicator. Family farm income is defined as gross output less net expenses (direct and overhead costs) and includes subsidy receipts. It does not include off-farm income. Including subsidies gives a more inclusive portrayal of the overall farm income attributable to the enterprise, and also captures farmers who participate in extension for the primary purpose of scheme assistance as well as those involved in more technical based programmes. Given that assistance with Single Farm Payment applications is an important extension service, including the subsidy effect in the dependent variable was prudent. Intuitively, a farmer receives a financial gain directly attributable to this process in a given year. However, as the payment was decoupled from production under the reform of the EU's Common Agricultural Policy, this subsidy effect would not vary over time, and thus differences in farm income would be based on other factors associated with farm performance. The dependent variable was transformed using its natural logarithm to remove the influence of outliers in the sample, to smooth the distribution of the data and to enable us interpret our coefficients as percentages.

The main independent or explanatory variable selected for the regression analysis was extension participation as a binary variable. This enabled the division of the sample into those that participated in extension over time and those that did not. Thus, participation was recorded with a value of 1 for any level of participation in Teagasc extension and 0 otherwise. This aggregated form of the variable ensured a level of impact across all forms of participation was captured ensuring the public expenditure 'value for money' element was assessed. Farm system, stocking density, soil type, land value, labour, age, off farm employment and size were included as controls on the prior expectation that they would affect farm performance. These controls also strengthen the instruments' exogeneity condition as each control reduces the effect of the error term on the instruments.

For the first instrument, the distance to the local Teagasc advisory office was expected to negatively influence the decision to participate in extension services (relevant), but not to affect personal characteristics of the farmer such as their innate ability or motivation that would affect farm family income (valid). Thus, it was expected to be correlated with the decision to participate in extension but be exogenous to the omitted variables contained in the error term. For example, a farmer located a significant distance from a local office may choose not to participate with extension services, but this distance is unlikely to affect their farming capabilities or farm performance. Moreover, the location of farms in Ireland is largely due to inheritance as opposed to a conscious choice of where to locate, and thus the distance to a local office is largely exogenous. Furthermore, Läpple and Hennessy (2015) argued that advisory offices may be strategically located in advantaged regions where impact is likely to be pronounced. For example, areas with suitable soil for intensive production may be targeted as ideal locations to base the provision of extension services, given dissemination benefits and likelihood of participation. Indeed, Anderson and Feder (2004) suggested that economies of scale were lost and coordination difficulties rose as advisory offices became decentralised from selected locations. However, in the case of Ireland the number and geographic spread of offices reduced this effect as farms were an average of 10.7 km from their nearest office of the 90 that existed pre 2009 and 11.7 km thereafter when the number of Teagasc advisory offices were rationalised. This instrument was calculated by measuring the geographic distance from each observation to the nearest local advisory office. This was done by taking the geographic coordinates of each local office, and measuring the distance from the geo-referenced codes for each observation derived from the Teagasc NFS. The distance to office can be classified as random given the nationwide spread of offices as evident from the map in Figure 7.

**Figure 7 Location of Public Extension Offices in Ireland 2000-2014**




The second instrument was the policy change with the introduction of the Single Farm Payment Scheme in 2005, which replaced previous coupled payment schemes with a decoupled payment based on an average calculated over a historical reference period (2000-2002). In other words, the value of this annual flat payment was based on production decisions taken in that period (O'Donoghue and Hennessy 2015) and therefore did not vary on a current annual basis. Teagasc (2006) reported a 20 per cent increase in client numbers credited to the complexities of the new scheme in 2005. Accordingly, the decision to participate in extension was influenced by the new scheme but did not directly affect the current farm performance. In addition, the timing of the introduction of the scheme was exogenous, as it was decided by policy makers and not farmers. Thus it also fulfils the exogeneity requirement for IV analysis. This binary variable was developed by assigning a value of 1 if the year was after 2005 and 0 if before. The two instruments were also interacted to examine the impact of distance given the policy change. In other words, was the effect of distance on the decision to participate in extension less influential once the new policy was introduced? It is expected that it would remain a negative relationship but not as pronounced in magnitude given the increased numbers of clients. This addition helped to improve the functional form and robustness of the final model.

Although it is important to be cautious with regard to the claim of validity with regard to instruments, formulating a strong argument in their favour is helpful (Murray, 2006;

Cawley and Meyerhoefer 2012). Thus, the instruments utilised here are based on the arguments above and these claims are further validated in the diagnostic results in terms of relevance and validity. Given these prerequisites, we have confidence that the instruments applied are effective in combating endogeneity in the results. Summary statistics of all variables are provided in Table 1.

**Table 1. Data Description and Summary Statistics**

| Variable | Description | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| FFI/ha | Family farm income (€) per ha | 456.60 | 434.52 | -1798.38 | 3572.29 |
| Ln FFI/ha | Log of family farm income per ha | 5.92 | 0.94 | -1.63 | 8.18 |
| Advisory Participation | = 1 if Teagasc client | 0.54 | 0.50 | 0 | 1 |
| Ln Land Value/ha | Log of land value per ha | -0.11 | 0.56 | -4.80 | 2.61 |
| Farm Size | No. of utilisable hectares | 38.03 | 34.55 | 2.80 | 1116.58 |
| Stocking Density | Total Livestock Units per ha | 1.36 | 0.63 | 0 | 4.80 |
| Ln Labour | Log of unpaid family labour | -0.06 | 0.51 | -4.61 | 1.43 |
| Age | Age of farmer | 55.13 | 12.22 | 17 | 90 |
| Years Agri ed | = 0.5 if short course ; = 2 if ag cert; = 4 if ag university | 0.68 | 0.98 | 0 | 4 |
| System: Dairy | = 1 if dairy | 0.12 | 0.32 | 0 | 1 |
| Dairy & Other | = 1 if dairy & other | 0.07 | 0.26 | 0 | 1 |
| Cattle Rearing | = 1 if cattle rearing | 0.17 | 0.38 | 0 | 1 |
| Cattle Other | = 1 if cattle other | 0.20 | 0.40 | 0 | 1 |
| Mainly Sheep | = 1 if mainly sheep | 0.12 | 0.33 | 0 | 1 |
| Tillage | = 1 if tillage | 0.05 | 0.21 | 0 | 1 |
| Region: Border | = 1 if farm is in the border | 0.20 | 0.40 | 0 | 1 |
| Dublin | region | 0.01 | 0.10 | 0 | 1 |
| East | = 1 if farm is in the Dublin | 0.09 | 0.28 | 0 | 1 |
| Midlands | region | 0.11 | 0.31 | 0 | 1 |
| Southwest | = 1 if farm is in the east region | 0.10 | 0.30 | 0 | 1 |
| Southeast | = 1 if farm is in the midlands | 0.14 | 0.35 | 0 | 1 |
| South | = 1 if farm is in the southwest<br>= 1 if farm is in the southeast<br>= 1 if farm is in the south region | 0.18 | 0.38 | 0 | 1 |
| Medium Soil | = 1 if soil is medium quality | 0.40 | 0.49 | 0 | 1 |
| Poor Soil | = 1 if soil is poor quality | 0.12 | 0.33 | 0 | 1 |
| Dist_advoff | Distance to advisory office (km) | 10.71 | 8.63 | 0 | 62.16 |
| SFPyr | = 1 if advisory client after 2005 | 0.66 | 0.48 | 0 | 1 |
| SFPYR*Dist | Interactive term for clients and distance | 7.40 | 9.16 | 0 | 62.16 |

*Note: all variables recorded over the period 2000-2013.*

Given this data, IV models were estimated analysing the impact on farm family income. The results are presented in the subsequent section.

**Results**

The results of the estimation models are presented in this section. Although we expect that OLS estimation would lead to bias in the results, these estimates are presented in addition to the IV estimates to illustrate the scale of the difference between both estimation methods when endogeneity concerns are addressed. Furthermore, the three instruments were inserted cumulatively to monitor each effect on the dependent variable and subsequent diagnostic statistics. Thus, in total four models were estimated, one using OLS, and the others using IV with one, two and three instruments inserted respectively.

*IV results – First stage results*

The results of the first stage of the IV process are presented in Table 2 confirming the relevance of the instruments on extension participation decisions.

**Table 2. First Stage Results of IV: Advisory Participation**

| | 1 Instrument | | 2 Instruments | | 3 Instruments | |
|---|---|---|---|---|---|---|
| Advisory Participation | Coeff. (SE) | p value | Coeff. (SE) | p value | Coeff. (SE) | p value |
| SFP Policy Change | 0.530 (0.010) | .000 | 0.531 (0.010) | .000 | 0.565 (0.016) | .000 |
| Dist. Adv Office | | | -0.002 (0.001) | .000 | 0.001 (0.001) | .649 |
| Interaction Term | | | | | -0.004 (0.001) | .004 |
| CD Wald F Stat | 2639.20 | | 1331.86 | | 891.43 | |

*Note: endogenous regressor (Advisory Participation), 3 instruments (Single Farm Payment year, Distance to advisory office and Interaction of both), additional explanatory variables included land value, farm system, labour, size, off farm job, age, region, stocking density & soil group. P value <.01 indicates statistical significance at 1% level, Cragg-Donald Wald F Stat measures relevancy of instruments; n = 8,951.*

The above table shows there is a jointly significant relationship between the instruments and the endogenous regressor. Individually, when one instrument is applied, the policy change is a significant explanatory factor in the decision to participate in extension services. When the distance to local office is added, both instruments remain significant at the 1 per cent level and the signs are as expected with the policy change positive and the distance negative. However, the magnitude of the distance instrument is relatively small. This could be due to the fact that there were 90 local Teagasc offices in existence before a restructuring plan was introduced in 2009. Thus the average distance increased

after the office closures as noted previously. Accordingly, the relative distances to local offices were not practically large. Once all three instruments are applied the distance becomes positive and insignificant. However, as the interactive term is included, this variable becomes significant and negative as expected showing the conditional influence of distance after the introduction of the policy change. The Cragg-Donald Wald F statistic illustrates the joint significance of the instruments and shows a strong positive relationship between all 3 instruments and the dependent variable in the first stage. In our case, the Stock et al. (2002) rule of thumb of 10 is easily exceeded and we can conclude that the instruments are relevant.

*IV results – Second Stage Results*

The second stage of the IV process involved inserting the predicted values of the endogenous regressor (now exogenous) from the first stage into the main structural equation and applying them to the dependent variable. Accordingly the results of the IV estimates for the main variable of interest are presented along with selected diagnostics in Table 3 for clarity with the full table of results including the control variable estimates available in Appendix A. The OLS estimates are also included for comparison.

**Table 3. IV Parameter Estimates: Model of log of Family Farm Income/ha**

| | OLS | IV – 1 Instrument | IV – 2 Instruments | IV – 3 Instruments |
|---|---|---|---|---|
| Extension Participation | 0.19*** (0.02) | 0.35*** (0.04) | 0.35*** (0.04) | 0.35*** (0.04) |
| R2 | 0.22 | | | |
| Centred R2 | | 0.22 | 0.22 | 0.22 |
| Sargan p value | | 0.00 | 0.81 | 0.30 |

*Note: additional explanatory variables included year, land value, farm system, labour, size, off farm job, age, region, stocking density & soil group; standard errors in parenthesis; * represents statistical significance of p values -*** for 1% significance, ** for 5% significance and * for 10% significance; full tables of results available in appendix A; Sargan Overidentification P Value >.1 means we fail to reject the null of the instruments are valid, not applicable with 1 instrument as equation is exactly identified; n = 8,951.*

The results presented here show that there are consistent positive returns to participating with extension services and all are significant across all models. The OLS results indicate a 19 per cent increase in family farm income per hectare ceteris paribus. However, as the OLS approach does not combat the endogeneity bias, the coefficients estimated for the IV models offer a more accurate prediction, and as evidenced in the table, this return is approximately 35 per cent across the three models with the instruments added

cumulatively. This finding is in line with previous findings in the literature (26% in Akobundu et al. 2004; 61% in Davis et al. 2012; 55% in O'Donoghue and Hennessy 2015). However, as this measure does not distinguish between the types of extension activity, the precision of individual impact is not captured. Furthermore as the purpose of this study was to include all forms of extension participation this measure includes subsidy receipts which although an annual flat rate payment, contribute substantially to family farm income, particularly across farm systems. The consistency of the estimates justifies the instruments as being strong predictors of extension participation and thus instrumenting it successfully to identify the causal impact of extension participation on farm family income per hectare. Interestingly these effects are estimated alongside the control variables as noted above. Of those controls, farm system, education, stocking density, land quality and off farm employment were important predictors of family farm income as expected. For example, dairy farmers showed an increase of 37 per cent per hectare compared to non-dairy systems under the IV approach as opposed to 34 per cent under OLS. Similarly tillage systems increased their impact under the IV to 29 per cent as opposed to 26 per cent under OLS. Conversely the effect of farm size was insignificant possibly due to the per hectare basis of the dependent variable and there was mixed evidence for different regions. Most other variables experienced a minimal change under both systems, but extension participation showed the largest increase. The full table of results for each model is provided in Appendix B.

Furthermore, the Sargan test statistics report p values exceeding significance values of 0.1 meaning we fail to reject the null hypothesis that the instruments are valid. Indeed as it is impossible to prove the null hypothesis of no effect based on the nature of the unobserved error term (Cawley and Meyerhoefer 2012), the Sargan statistic reverses the process and in this case the null is that the instruments have an effect, and we fail to reject that claim. In other words, these instruments can be argued as valid in addressing the endogeneity issue of extension participation, and thus our estimates provide a consistent and positive impact on farm family income per hectare.

The results of the analysis demonstrate that extension services had a positive impact on farm income over the period 2000-2013.

**Conclusion**

While much of the previous literature had identified a positive relationship between participation in extension services and farm level outcomes, the IV approach presented here provides a robust estimation that comprehensively addresses endogeneity concerns. In line with previous literature the IV estimates of the impact of extension services are uniformly higher than the OLS estimates (Card 1993; Cawley and Meyerhoefer 2012). Therefore, there is a clear indication of a net benefit to extension participation in the first instance.

Identifying appropriate instruments is the critical challenge of the IV approach particularly in terms of confirming exogeneity to the error term, and thus estimates should be interpreted with caution (Cawley and Meyerhoefer 2012). However, in this analysis the distance to the local advisory office and policy change instruments were relevant to the decision to participate in extension and valid in terms of uncorrelated to the dependent variable and error term based on both argument and the diagnostic tests, and thus, the results presented are superior estimates of the impact of extension services on farm income.

In terms of policy implications, the results suggest there is a causal positive effect of participating in extension programmes in terms of farm income. Furthermore, these findings are unbiased implying that the impact is greater than previously thought and therefore the role of extension as a policy tool is effective. Thus, the benefits of extension participation should be more widely promoted among farmers to encourage increased engagement that can be leveraged to achieve policy goals. For example, if governments aim to grow agricultural output, an extension programme could be targeted to provide technical assistance to bolster productivity through improved feed management to increase overall output levels. Conversely, farms could be targeted with environmental advice to curb greenhouse gas emissions as set out in international regulations. A more targeted approach that incentivises deeper forms of engagement may be valuable (Akobundu et al. 2004), but this requires further analysis to identify the effect of different levels of extension engagement. Nonetheless, policy targets set for the agricultural sector by government should be adequately supported by a dynamic effective extension service.

This study provides a robust estimation of the impact of extension services across all farming sectors on an aggregated basis in Ireland. However, there are a number of caveats

that should be considered when utilising an IV approach, and further research is needed to enforce the findings provided here. Firstly, when applying the IV approach the validity of the instruments is key. Although we have confidence and the results defend their validity, it is logical to assume there may be alternative instruments that could be used that are not available in this dataset. For example, the neighbour or peer effect could have been instrumented as farmers may be more likely to become clients based on their peers' participation. Similarly, the availability of advisers could have been a useful instrument given the drop in numbers due to retirements over the same period reducing the availability of services. However, both of these instruments were not possible due to data limitations. Moreover, the distance to advisory office instrument could prove more effective if the offices were classified according to the types of services offered as smaller offices may not have the facilities to address more intensive forms of extension participation. Similarly, the endogenous variable used here is a dummy and thus does not reflect the variability of extension programmes available, and thus, cannot rigorously distinguish different types of extension participation nor assess their impact. Distinguishing on the basis of the motivation to participate would enrich the analysis further. Indeed, the knowledge transfer effect is not homogenous, but more likely to be heterogeneous in nature (Coccia 2008). However, this research provides a foundation to build upon as the IV approach delivers a more precise and unbiased estimate of the positive effect of extension advice to farms, ensuring that the 'value for money' objective for policy makers is met. This is an important first step in the evaluation of impact and future research could aim to identify the impact of different types of extension.

# Chapter 5 – Quantitative Analysis II: The Effect of the Economic Recession on Knowledge Transfer Delivery and Impact on Farm Level Margins[2]

## Introduction

Knowledge transfer (KT) is a key aspect of agricultural sector policy delivered through public and private extension organisations. KT provision has the ability to diffuse best practice farm management and technologies to the agricultural sector (Tamini 2011). This occurs as a result of enhancing client capabilities through improved problem solving skills, decision making and more effective farm management through an efficient KT service (Vanclay and Leach 2011). Public KT services can act as policy levers to influence farmer behaviour and therefore assist in achieving policy objectives such as sustainable production, environmental mitigation and food safety legislation (O'Donoghue and Hennessy 2015). Thus, it is essential that the KT services operate efficiently to support the implementation of varied initiatives across a range of outcomes. However, providing an efficient public agricultural advisory service is confronted with many challenges including fiscal obligations and the dependence on the broader policy environment (Anderson 2008). It is imperative that public KT bodies deliver impact on farm level, notwithstanding their financial responsibility to the taxpayer. In other words, the service must represent 'value for money' to ensure its continued relevance and validity.

This impact can be quantitatively evaluated to assess whether participation is of benefit to the farmer, which in turn highlights the value for the organisation in providing the service. Accordingly, a robust evaluation of existing KT services is a pertinent exercise to continually develop and provide an efficient service with an evidence based quantifiable rate of return for the recipient farmer (Kidd et al. 2000). Indeed, such studies on evaluating impact in agricultural extension services have increased since the mid-2000s (Faure et al. 2012). Quantitative analyses provide methodological options where results can be generalised to a larger population dependent on the validity and reliability of the sample and the statistical procedures employed (Plano Clark and Ivankova 2016). These results are more simplistic to translate to policy makers to quantify the impact a particular mechanism to achieve its desired objectives (Johnson and Onwuegbuzie 2004).

[2] Accepted for publication: Cawley, A., O'Donoghue, C., Heanue, K., Hilliard, R. and M. Sheehan (forthcoming) "The Impact of Knowledge Transfer on Farm Level Margins during the Economic Recession: A Quantitative Study." *The Journal of Agricultural Education and Extension*

This study provides one such evaluation of KT impact on farm level profitability, but does so during a period of diminished resources restricted by constraints enforced by the economic crisis.

This study focuses on the Irish example, where the public KT provider Teagasc retains a predominantly public funded KT service alongside its research programme unlike many other European countries (Läpple et al. 2016; Prager et al. 2016). During the economic crisis Teagasc consolidated its services leading to a 43.4% decline in the number of local offices and a 38.4% decline in adviser numbers, despite a comparatively minor 4.5% drop in client numbers. This implied a significant change in the allocation of resources to meet client demand. Accordingly, an evaluation on the impact of KT on farm level profitability in this context would inform the effect of the increased demand on remaining resources. This evaluation can be quantitatively assessed by merging an administrative data with the Teagasc National Farm Survey (NFS), which is a panel data set that provides information on farm level financial performance. This will identify the implications of this consolidation on the delivery of impactful KT to farm level, by quantifying the level of financial benefit received by KT clients during this period as well as the consequence of the reduction of resources.

Several studies evaluate the impact of agricultural KT on farm level profitability (e.g. Davis et al. 2012; Dercon et al. 2009; Läpple and Hennessy 2015) and typically the results are varied given the multiple methodological options and the diverse range of outcomes (Anderson and Feder 2004; Läpple and Hennessy 2015). However, many quantitative studies take a national perspective on the outcome as opposed to disentangling the relationships by region or on the allocation of available resources. Läpple et al. (2016) offer one such exception in terms of knowledge spillover and found significant differences between Irish regions in terms of access to KT services as well as across farm systems. Specifically, they found that counties located in the south east had lower client adviser ratios in contrast to counties in the western region. The analysis presented here builds on this work by focusing on farm level margins for KT participants whilst applying random effects regression techniques to quantify the impact during the economic crisis from 2008-2014. This extends existing knowledge on impact by linking to a period when the level of available resources was reduced, resulting in an increased workload particularly in terms of the ratio of clients assigned to each adviser. Thus, the ability of a KT service to respond to an economic shock and maintain an impactful service is tested, which extends on existing literature by conditioning on the access of farmers to the KT

service, an area identified by Faure et al. (2012) for further research. This will provide a valuable contribution to future policy discussions on the deployment of resources for public KT providers, by providing evidence on the level of value attributed to delivering the service.

The remainder of the paper is structured as follows: initially the context for agricultural KT in Ireland is outlined along with the research questions, followed by a review of the relevant literature. Next an overview of the methodology is provided and the data is described. Finally the results are discussed and conclusions drawn which outlines some caveats and direction for future research.

**Context**

The role of agricultural KT is wide ranging and incorporates a plethora of objectives. Concomitant with conventional tasks of providing technical assistance to farmers to improve productivity, KT providers must also balance emerging functions on issues such as environmental protection, sustainability and linking small farm holders to high value export markets (Anderson 2008). There is also a substantial scheme assistance element to KT as advisers help to ensure farmers realise their financial subsidy entitlements. Thus, the primary objective of a KT service is to provide assistance and expertise to farmers to improve their situation in specific contexts, by overcoming barriers such as a lack of knowledge, influence or natural and capital resources (Van den Ban and Hawkins 1988).

KT is provided by both public and private organisations distinguished on the basis of 'interest' with public bodies funding activities related to public interest issues as opposed to primarily serving private interests aligned to profit generation (Klerkx and Leeuwis 2008). On this basis, governments have a legitimate need to influence farmer behaviour through a mixture of regulation, incentives, and advice (Garforth et al. 2003). Nonetheless it is imperative that KT providers utilise their resources efficiently to maximise their impact to justify their significant subsidisation from public expenditure. In addition, KT clients often have to pay some level of fee for service (Garforth et al. 2003), and thus it is important that clients also experience a financial gain from participation. Ultimately, achieving 'value for money' is the common goal for both the provider and recipient.

There are various forms of agricultural KT with diverse levels of interaction and learning methods involved. More recently, it has been argued that traditional linear formats were in decline with an increasing role for participatory forms that promote learning through

peer interaction (Cliffe et al. 2016; Läpple et al. 2016). This reflects a move from the top-down model to a more horizontal format where knowledge is shared under the facilitation of an adviser (Black 2000; Garforth et al. 2003). In addition, one-to-one consultations have retained their importance with private KT organisations providing much of this individualised work as opposed to the multifunctional role of the public organisation (Prager et al. 2016). Structured educational programmes are also an important KT typology where students learn in a class based environment (Black 2000). Each form reflects the diversity in the methods to attract, communicate and transfer specialised knowledge from the research or policy arena to farm level. Therefore it is important to avoid a generalised 'one-size-fits-all' model, given the diversity among the knowledge base of recipients (Asheim and Coenen, 2005; Pannell et al. 2014).

However, the spatial availability of these activities is often asymmetrical given organisational challenges such as the mobility of staff, client densities, or practical issues such as the location of farms. Furthermore, an increasingly heterogeneous market for agricultural KT may lead to certain market failures due to this asymmetry of information or the perception of service value (Klerkx and Leeuwis 2008). This poses additional challenges for evaluation as a farmer located in an area with a lower level of access to KT, may be less likely to participate intensively, thus less likely to receive the same level of impact as a farmer located in an area with higher access and service options. Therefore, the inclusion of office based characteristics is necessary to account for this asymmetry when evaluating impact.

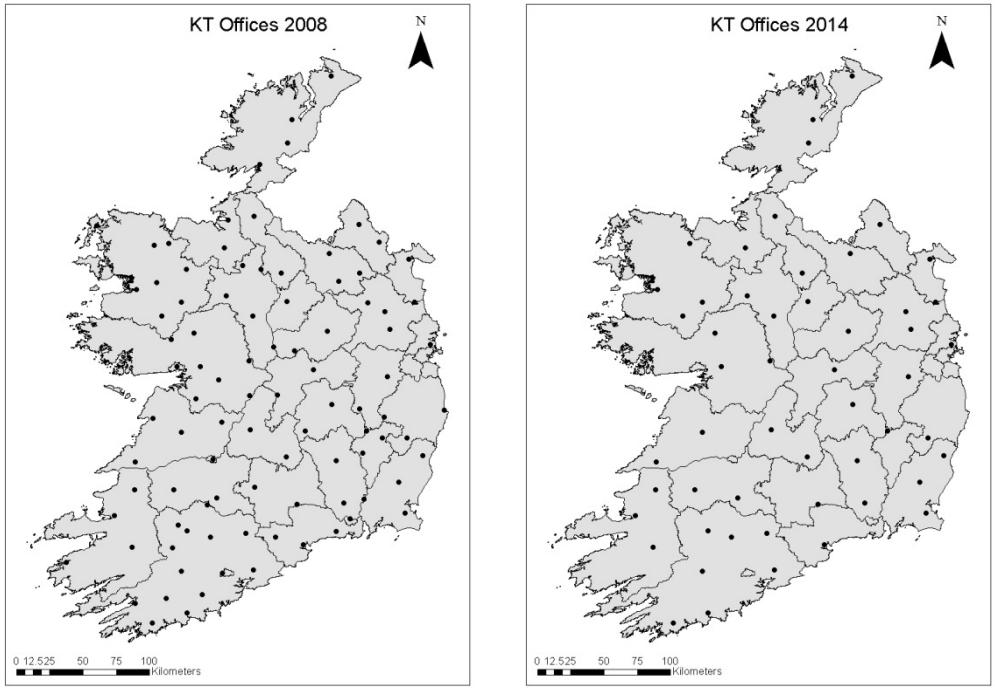
In addition, KT offices may be strategically located in advantaged regions where impact is likely to be more pronounced (Läpple and Hennessy 2015). For example, particular areas may be chosen as more suitable for intensive forms of production based on the soil type which may then be selected as ideal locations to base the provision of KT services, given dissemination benefits and likelihood of participation. Conversely, mountainous areas characterised by more marginal land may not appeal to KT providers given lower profitability expectations and lower participation rates. Thus, the location of KT centres is based on the needs of specific stakeholders or target audiences from a practical and in some cases politically feasible point of view (Leeuwis 2004). However, public KT providers must ensure access to meet the demand for KT services and assure public good benefits above what would be expected in a private organisation (Anderson and Feder 2004; Faure et al. 2012; Kidd et al. 2000). Indeed, it has been argued that smaller scaled farmers will suffer a lack of access if KT services are solely the function of private

enterprises (Anderson and Feder 2004; Labarthe and Laurent 2013). This additional responsibility to ensure access for public KT providers is an important consideration for the deployment of resources particularly in a consolidation process, and accommodating this issue is a key methodological challenge addressed in this analysis.

*Teagasc KT*

Teagasc is unique in that it operates an organisational structure that recognises the importance of combining research with effective KT (Prager et al. 2016) by allocating 70% of their operating budget of €160 million per annum between the two key pillars of the organisation (Teagasc 2016). This structure ensures that technologies and practices discovered in research can be transferred efficiently to clients to improve their farm level performance. Nonetheless, Teagasc was forced to consolidate resources from 2008 to 2014 due to fiscal challenges due to the economic recession. This reemphasised the need to commit to the efficient deployment of resources to pursue the priorities of the organisation which required adaptation and change to maximise impact (Boyle and Cawley 2009). Specifically, this involved a significant reduction in resources involving the disposal of assets, office closures, staff reductions and redeployments (Cawley and Boyle 2011). Forty local advisory offices were closed (a decline of 43.4%), and adviser numbers were reduced by 145 (a decline of 38.4%). Consequently, the spatial dispersion of existing KT offices widened which increased distances to their nearest retained office for KT clients. All regions were affected. The scale of office closures is illustrated in Figure 8. Teagasc client numbers remained relatively static at 41,025 (a slight decrease of 4.5%) over this period.

**Figure 8 KT Office Closures 2008-2014**

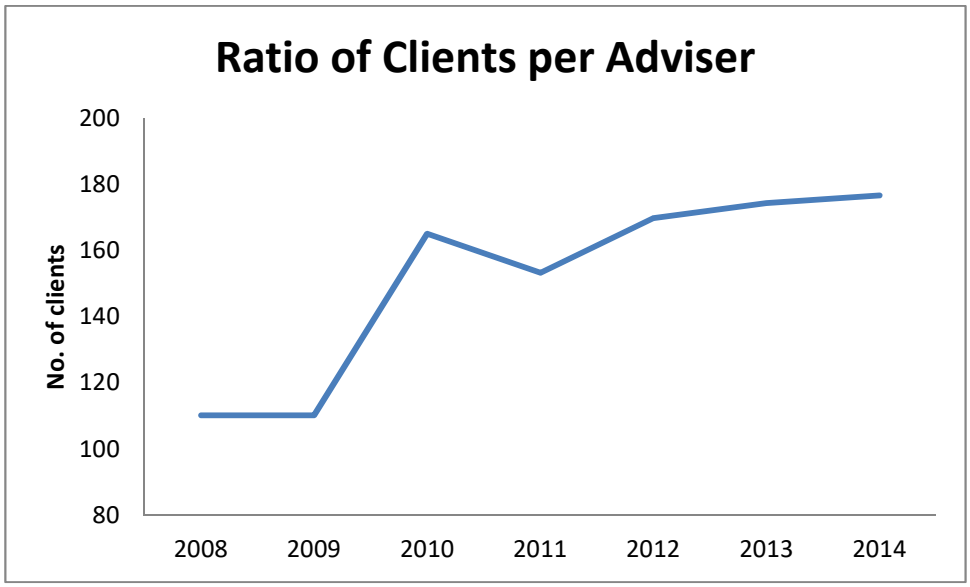



Evidently, the closure of offices increased the distances to the nearest office for farmers over this period. This increase was marginal with an additional 7 kilometres on average reaching a maximum increase of 17.8 kilometres overall with 52 offices retained, therefore ensuring the organisation remained accessible to farmers (Prager and Thomson 2014). However, this does not reflect the increased distances in specific regions accurately, with the distances in the north western region increasingly disproportionately to those in other areas. Specifically, the western region experienced a trebling of average distance compared to other regions.

Similarly, the ratio of clients per adviser increased significantly, and differed considerably by region. Nationally, the ratio increased by 55.1% on average (see Figure 10). However, the west region experienced an increase of 79.8% whereas in the southwest the increase was 13.5%. Furthermore, particular services were relocated in an attempt to meet demand for particular KT activities with reduced resources. Taking the agricultural training courses as an example, smaller offices relinquished this service to larger KT centres to facilitate larger groups and maximise efficiencies from the KT service. The increased ratio of clients per adviser over this period is presented in Table 4. In general most local offices experienced a significant rise in the number of clients assigned to each adviser as a result of the consolidation. These varied regionally but on average the increase was 48 additional clients to each adviser. On a regional basis the ratio of clients

to advisers was recorded as lowest in 2014 in the south west at 124 clients per adviser on average. Conversely, the highest ratio was recorded in the west over this period with 212 clients per adviser in 2014, an increase of 80% from the 2008 level reflecting the dramatic change over the period. These ratios reflect a North/South divide as well as providing evidence to support the East/West divide found by (Läpple et al. 2016). Furthermore, the range of ratios across the country became increasingly skewed, from a range of 106-118 clients in 2008 to 124-212 clients in 2014. Thus, the difference rose from 12 clients to 88 clients per adviser on average. These ratios are significantly higher for Irish KT than for international counterparts such as the UK, Belgium and Italy where public KT based ratios showed a median of 80 clients per adviser (Prager et al. 2016). This implies that advisers would have less time for individual consultations with clients and may have had to facilitate additional clients in group based formats of KT.

**Figure 9 Average Ratio of Clients per Adviser 2008-2014**



The following table illustrates the change in client ratios and average profit level for clients during the period being studied.

**Table 4. Regional Change from Consolidation**

| Region | Mean MGM per ha 2008 | Mean MGM per ha 2014 | Percentage increase | Clients per adviser 2008 | Clients per adviser 2014 | Percentage increase |
|---|---|---|---|---|---|---|
| Border | €433 | €624 | 44%** | 112.5 | 195.6 | 74%*** |
| Dublin | €580 | €872 | 50% | 110.0 | 190.5 | 73%*** |
| Mid-East | €679 | €868 | 28%* | 109.2 | 171.7 | 57%*** |
| Midlands | €577 | €762 | 32%** | 119.2 | 180.8 | 52%*** |
| Mid-West | €512 | €986 | 93%*** | 106.6 | 188.2 | 77%*** |
| South-East | €734 | €1,135 | 55%*** | 119.9 | 175.0 | 46%*** |
| South-West | €731 | €1,122 | 53%*** | 109.6 | 124.4 | 13%** |
| West | €199 | €422 | 112% | 118.2 | 212.6 | 80%*** |

*Note: Border counties include Louth, Leitrim, Sligo, Cavan, Donegal and Monaghan; Mid-East include Kildare, Meath and Wicklow; Midlands include Laois, Longford, Offaly and Westmeath; Mid-West include Clare, Limerick and North Tipperary; South-East include Carlow, Kilkenny, Wexford, Waterford and South Tipperary; South-West include Cork and Kerry; West include Mayo, Galway and Roscommon; Market gross margin is calculated by deducting direct subsidy payments from farm gross margin and refers to Teagasc clients only; Ratios are aggregated from local office data within each region; * represents statistical significance of p values: *** for 1% significance, ** for 5% significance and * for 10% significance*

Evidently, some regions were affected more than others in the consolidation process, which implies uneven access to KT services (Läpple et al. 2016). However, all regions experienced an overall increase in the ratio of clients, and the impact of this increase on profitability is the key focus of this analysis.

*Research Questions*

1. What was the impact of the rationalisation of KT resources on farm level profitability?

2. How can the use of available panel data contribute to policy decisions on the deployment of KT resources?

**Literature Review**

Much of the literature on the impact of KT services on agricultural profitability primarily adopts KT as an aggregated binary variable and outcomes are measured on the basis of participation versus non participation. Typically these types of analyses are undertaken on a national basis (Cawley et al. 2018; Davis et al. 2012; Läpple et al. 2013; Läpple and Hennessy 2015). However, there are a limited number of studies that focus on the regional or spatial aspect of how KT is delivered and absorbed by clients (Läpple et al. 2016), with none focusing on the delivery of KT during a period of recession. To distinguish between regions, and isolate causal relationships based on a service that offers a multiplicity of diverse services on a wide ranging set of outcomes is central to these difficulties. This paper addresses these gaps in the literature by focusing on the spatial characteristics of KT resources for each KT office, their deployment of resources to provide the service and the subsequent impact on farm margins for clients.

However, basing the analysis purely on location may not suffice to explain the impact of KT (Fisher 2013). Rather it is important to consider the type and quality of KT received as a central objective and particularly the number of clients assigned to each local adviser as an indicator of adviser access (see Läpple et al. 2016; Prager et al. 2016). For example a recent study found that although farmers received more than one visit from extension agents on an annual basis, the impact of these visits was questionable (Onobougo et al. 2014). Their study suggests that multiple visits would be beneficial to farmers but this was not the case for the majority who received fewer on-farm consultations. Furthermore, the ability of advisers to provide multiple farm visit based consultations is dependent on their availability. To address this issue in this study although we also aggregate KT participation into a binary variable, we focus only on annual contract holders implying the KT received is aimed at more intensive technical advice as opposed to other objectives such as scheme assistance duties. Teagasc annual contracts vary from a basic package that does include some scheme assistance as well as invitations to events and up to date news publications to an intensive development package that includes discussion groups and intensive on farm consultations. Indeed the failure to control for clients who are motivated by the scheme assistance offering may lead to mistakenly identifying a subsidy effect as a KT effect (Nordin and Höjgård 2016).

Läpple et al. (2016) addressed spatial variability in their analysis on knowledge spillover in Ireland and found a clear regional divide given the distribution of research and KT

services. Utilising a proxy based on farmers participating in non-scheme related KT and geographic information system (GIS) maps they regressed their variables using a Tobit model to draw these conclusions. However, their work was primarily focused on the spatial concentration of agricultural innovativeness based on an index whereas in this paper we focus on farm margin ensuring a financially comparable outcome measure. Similarly Coccia (2008) conducted research into the spatial mobility of KT in Italy by developing a function based on the number of contacts with a knowledge centre and the distance to that centre and found that technology adoption decreases as the distance to the centre increases. Again this work shows that spatial factors are likely to affect the outcome of KT participation, but the focus is limited to technology adoption as opposed to farm level profitability. A similar study was conducted on the effectiveness of extension outlets to influence technology adoption and concluded that it is imperative that offices are located strategically close to target peer farms in remote areas to ensure widespread diffusion of information. Genius et al. (2013) found that extension provision should be sought to complement existing informal social networks to ensure effective knowledge transfer.

Broadening the focus outside of agriculture there are examples in the literature that focus on the spatial effects associated with KT. For instance, a relationship between concepts such as strong social capital ties, cohesion, trust built within a network and effective KT have been reported (Inkpen and Tsang 2005; Reagans and McEvily 2003). These imply that locally based networks that have endured over time gain additional benefits due to factors such as familiarity, relevance and collective action. Agricultural KT providers have also provided more participatory formats of extension where familiarity and peer learning are key elements (Garforth et al. 2003). However, the extent to which these forms continued to impact farm margin during a period of resource constraint has not been researched in detail, and will help to provide valuable lessons for future resource deployment.

This analysis extends on existing literature in two distinct ways. First, the analysis utilised a random effects estimator to control for individual biases by exploiting the panel nature of the data set. Second, the analysis focuses on the impact of KT on farm level profitability through a period economic recession with an associated impact on the deployment of resources. This is achieved by merging two datasets to evaluate the impact over an economically turbulent period where the importance of the agricultural sector in Ireland was key to the recovery, with a faster export growth rate than other sectors over

the period 2008-2013 (O'Donoghue and Hennessy 2015). The impact of the KT service in assisting this growth would highlight the importance of assisting farmers in improving performance (Ingram and Morris 2007), and justifying the need to adequately resource public KT bodies to continue to meet policy objectives (Coccia 2008).

## Data

The data for this research is two-fold. First data on KT participation and farm performance was obtained from the Teagasc National Farm Survey. Second, data on KT provision was derived from internal administrative records in Teagasc to identify existing offices and the respective number of advisers and clients in each.

### *Teagasc National Farm Survey (NFS)*

The NFS is an annual panel data set collected as part of the Farm Accountancy Data Network of the European Union consisting of approximately 1,000 farms per annum. The panel is unbalanced in the sense that farms do not always remain permanently in the sample (Hynes and Garvey 2009). This dataset provides data on the level of output, margins, costs, income, investment and indebtedness across the spectrum of farming systems, sizes and profiles in the various regions (Connolly et al. 2010). It also indicates whether a particular farmer was a Teagasc client providing an indication of KT participation as well as the type of participation. The data was obtained for the years 2008-2014 inclusive to examine impact since the organisational change was implemented. The panel data format will also enable to track the rate of return on farms from knowledge transfer with authors arguing the benefits may deteriorate over time (Anderson and Feder 2004), or perpetually increase (Läpple and Hennessy 2015). This provides a valuable dataset to conduct the analysis which can highlight the impact of existing services and direct future resource deployment.

### *Administrative Data*

The rationalisation programme initiated meant the closure of 40 local offices leaving 52 offices open, a decline of 43.4%. In addition, there were statistically significant reductions in the numbers of advisers available a fall from 377.5 in 2008 to 232.2 in 2014, a decline of 38.4%. Concurrently, the number of clients during this period remained relatively static with 42,994 clients in 2008 as opposed to 41,025 in 2014 indicating a slight decrease of 4.5%. This implies an increase in the ratio of clients to advisers as shown in Figure 3.

This ratio can be adopted as an indication of KT provision and thus used for assessment (Prager et al. 2017), and varied spatially as noted previously. These ratios appear higher in the regions that would be considered less favoured in terms of land capability, with farm systems associated with lower incomes such as beef and sheep more common. Conversely, dairy farmers are more common in regions with lower ratios such as the south east and south west (Läpple et al. 2016). The location of each office was obtained by applying their specific Building Identification code from the Irish postal service's Geo-reference directory, and measuring the geographic distance to each farm observation in kilometres. It is expected that the distance to a local office negatively affects the decision to participate in KT services.

*Key Variables*

The dependent variable for this analysis is market gross margin per hectare defined as all income attributed to the farm enterprise excluding subsidies. This provides an indication of the financial performance of farm related activity based on the value of their output. The main explanatory variable is based on advisory contracts which exclude scheme assistance and other services. These contracts are assumed to involve more technically based KT to various levels of intensity including one-to-one consultations, farm walks, discussion group activities and access to the most recent research. Therefore the key assumption is that KT clients with annual contract are motivated to participate to improve their technical expertise and thus improve their market gross margin. The ratio of clients per adviser is also adopted as a key explanatory variable to reflect the impact of the organisational consolidation process. This variable was calculated by taking an average ratio of clients per adviser in their local KT office, which was calculated by measuring their nearest office using the geo reference coordinates as outlined above. This ensures that the impact of the recession on resource deployment is reflected at a local level.

In addition to the variables listed above, appropriate controls are included to explain the variation in market gross margin including farm system, land type, and personal characteristics such as farmer age, education and off farm employment. Regional dummies were included for 8 regions nationally, but the main variables were estimated at a local level. However, these dummies did help to illustrate the regional differences in the ratios for additional context. The sample is drawn from Teagasc clients only to ensure the analysis focuses on a similar cohort of farmers that are assumed as more progressive. The summary statistics are presented in Table 5.

**Table 5. Data Description and Summary Statistics**

| Variable | Description | Mean | SD | Min | Max |
|---|---|---|---|---|---|
| MGM/ha | Market gross margin per ha | 755.6 | 719.8 | -762.5 | 8333.3 |
| Ln MGM/ha | Log of market gross margin per ha | 6.210 | 1.193 | -1.516 | 9.03 |
| KT contract holder | = 1 if Teagasc contract holder | .74 | .44 | 0 | 1 |
| Clients per adviser | Ratio of clients per adviser in office | 156.6 | 23.5 | 102.9 | 232.1 |
| Region: Border | = 1 if farm is in border region | .18 | .38 | 0 | 1 |
| Dublin | = 1 if farm is in Dublin region | .01 | .09 | 0 | 1 |
| East | = 1 if farm is in eastern region | .11 | .31 | 0 | 1 |
| Midlands | = 1 if farm is in midlands region | .12 | .33 | 0 | 1 |
| Midwest | = 1 if farm is in mid-west region | .08 | .27 | 0 | 1 |
| Southeast | = 1 if farm is in southeast region | .18 | .38 | 0 | 1 |
| Southwest | = 1 if farm is in southwest region | .20 | .40 | 0 | 1 |
| West | = 1 if farm is in the western region | .12 | .33 | 0 | 1 |
| Ln Land Value/ha | Log of land value per ha | -.11 | .54 | -3.92 | 2.70 |
| Dairy | = 1 if system is dairy | .31 | .46 | 0 | 1 |
| Cattle Rearing | = 1 if system is cattle rearing | .14 | .34 | 0 | 1 |
| Cattle Other | = 1 if system is cattle other | .23 | .42 | 0 | 1 |
| Mainly Sheep | = 1 if system is mainly sheep | .11 | .31 | 0 | 1 |
| Pigs & Poultry | = 1 if system is pigs & poultry | .00 | .03 | 0 | 1 |
| Tillage | = 1 if system is tillage | .10 | .29 | 0 | 1 |
| Other | = 1 if system is other | .12 | .32 | 0 | 1 |
| Forestry | = 1 if farm has forestry | .13 | .33 | 0 | 1 |
| Farm Size | No. of utilisable hectares | 58.05 | 47.09 | 0 | 1116.6 |
| Stocking Density | Total livestock units per ha | 1.40 | .67 | 0 | 4.26 |
| Labour | Units of unpaid family labour | 1.24 | .49 | 0 | 3.83 |
| Age | Age of farmer | 54.6 | 11.63 | 21 | 90 |
| Years Agri ed | = .5 if short course ; = 2 if ag cert; = 4 if ag university | .97 | 1.05 | 0 | 4 |
| Off farm job | = 1 if employed off farm | .21 | .41 | 0 | 1 |
| Good soil | = 1 if soil is classified as good | .56 | .50 | 0 | 1 |
| Medium soil | = 1 if soil is classified as medium | .34 | .47 | 0 | 1 |
| Poor soil | = 1 if soil is classified as poor | .09 | .29 | 0 | 1 |
| Dist_advoff | Distance to advisory office (km) | 15.27 | 8.06 | 0.15 | 52.39 |

*Note: All summary statistics based on Teagasc clients only*

## Methodology

Although access to quality KT services is the key theme of this research, simply having access to the service cannot be assumed productive in terms of impact and thus there are many dynamic factors that explain this process (Fisher 2013). Accordingly, there is an inherent difficulty in evaluation of these types of KT services given the broad range of extension methods and outcome measures (Läpple and Hennessy 2015). Indeed, there are many underlying issues that also affect farm performance (Anderson 2008), such as omitted variables on farmer characteristics and self-selection biases due to the voluntary nature of participation (Imbens and Wooldridge 2009; Nordin and Höjgård 2016).

Nonetheless given the core objective of this research of estimating the impact of KT on farm margins, a random effects regression model was chosen as most suitable given the panel nature of the data acquired and the inherent biases due to the influence of confounding factors. An instrumental variable approach was considered on the basis of its efficiency at combating all forms of bias (Cawley et al. 2018), but no suitable instruments were found. The random effects approach provides a valuable alternative in that it exploits the panel nature of the Teagasc NFS dataset and controls for heterogeneous unobserved variables by allowing for individual-specific controls (Gujarati 2003; Howley et al. 2012; Kilcline et al. 2014). This helps to reduce the level of bias associated with each observation.

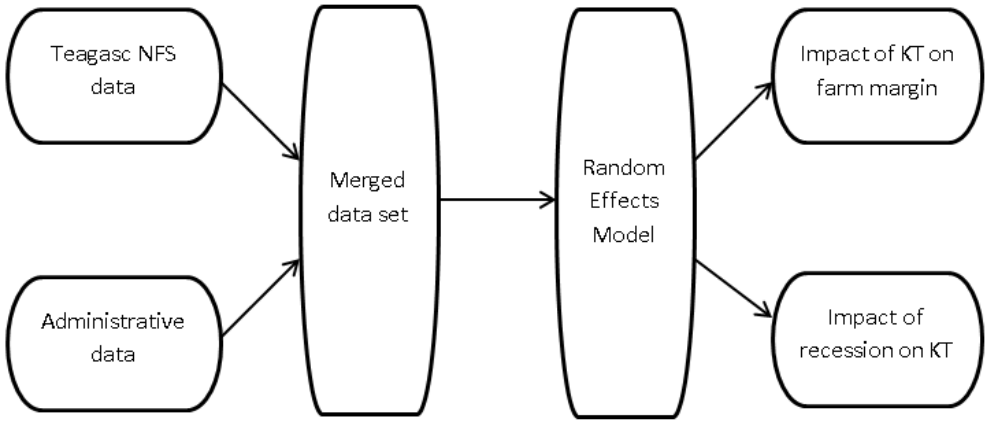
The random effects model is preferred on the basis of two selected criteria. Firstly, random effects models assume that all explanatory variables are uncorrelated with the individual effects (Baltagi and Liu 2012; Gujarati 2003). In other words, the individual effects of each observation are assumed to be random. This enables the individual component associated with the heterogeneity of each observation to be absorbed through the error term (Kilcline et al. 2014). Second, although a Hausman test suggests a fixed effects model for this analysis, the lack of variation across years in terms of farm system and nearest office characteristics causes many observations to drop out as they remain static (Wooldridge 2013). Thus we retain valuable information through the random effects estimator that adds to the model to explain the variation in farm margin.

Accordingly the model is specified as follows:

$$\Upsilon_{it} = \alpha_i + \beta \mathbf{X}_{it} + \varepsilon_{it}$$

where $\Upsilon_{it}$ is the dependent variable of market gross margin per hectare for farm i in year t, $\alpha_i$ is the individual farmer effect, X is a vector of explanatory variables including KT annual contracts, the spatial variables outlined above and controls and $\varepsilon$ is the idiosyncratic error term. Furthermore the standard errors are adjusted to control for any heteroscedasticity concerns. Figure 10 summarises the method of analysis for this study.

**Figure 10 Method of Analysis**




In short, the analysis creates a data set that includes farm performance measures through the Teagasc NFS with data on the deployment of resources through the administrative data. A random effects model is then employed to estimate the impact of KT on farm level profitability as well as the impact of the reduction in resources deployed.

**Results**

First, contract holders experienced a positive impact to KT participation on their market gross margin. The value of this impact was estimated at 12.3% and was statistically significant. Second the increased ratio of clients per adviser negatively impacted participants, but this effect was practically small per additional client at 0.2%. This means that for each additional client assigned to an adviser, the overall margin of that client decreased by 0.2%. While this may seem practically insignificant as advisers typically manage large numbers of clients, once the total increase in clients is assumed, the decrease becomes more significant. Thus, given that during this period of consolidation,

advisers gained an additional 48 clients each on average, this effect implies a cumulative negative effect of 9.6 % on market gross margin per hectare on average.

Furthermore given that these ratios vary considerably from region to region, the effect of the additional clients was asymmetrical with areas in the north and western regions more likely to have experienced a larger negative effect. For example, an adviser located in the western region experienced an increase of 94.4 clients, which implies a decrease of 18.9% on average market gross margin per hectare. Conversely, an adviser in the south west region experienced an increase of 14.8 clients implying a decrease of just 2.9% on overall gross margin per hectare. Therefore, the regional disparities increased over this period, with a north/south divide evident in terms of impact. However, it is also important to note that the more northerly regions are more likely to rely more heavily on subsidy payments due to a variety of factors including the lower profitability of the dominant beef and sheep systems, and associated limitations on land capability compared with other regions. Thus, including subsidies in the model is likely to reduce this spatial imbalance, and the inclusion of subsidies in the dependent variable increases the impact of KT participation on farms to 17.1%, therefore offsetting the negative effect of the consolidation further. However, for the purpose of clarity this analysis focused on profitability excluding subsidies. The full set of results is presented in Table 6.

**Table 6. Random Effects Model Coefficient Estimates**

| Variable | Coefficient | SE | p | Confidence Interval | |
|---|---|---|---|---|---|
| KT contract holder | 0.123 | 0.053 | 0.021 | 0.018 | 0.227 |
| Clients per adviser | -0.002 | 0.001 | 0.054 | -0.004 | -0.000 |
| Region: Dublin | 0.214 | 0.153 | 0.160 | -0.085 | 0.514 |
| East | -0.005 | 0.085 | 0.949 | -0.171 | 0.160 |
| Midlands | 0.032 | 0.086 | 0.711 | -0.137 | 0.201 |
| Midwest | 0.071 | 0.078 | 0.361 | -0.081 | 0.224 |
| Southeast | -0.004 | 0.075 | 0.960 | -0.143 | 0.151 |
| Southwest | -0.071 | 0.076 | 0.347 | -0.219 | -0.077 |
| West | -0.251 | 0.102 | 0.013 | -0.451 | -0.052 |
| Ln Land Value/ha | 0.062 | 0.043 | 0.149 | -0.022 | 0.146 |
| Cattle Rearing | -1.230 | 0.067 | 0.000 | -1.362 | -1.098 |
| Cattle Other | -1.114 | 0.052 | 0.000 | -1.243 | -1.038 |
| Mainly Sheep | -1.113 | 0.077 | 0.000 | -1.285 | -0.985 |
| Pigs & Poultry | -1.244 | 1.336 | 0.352 | -3.862 | 1.374 |
| Tillage | -0.382 | 0.078 | 0.000 | -0.535 | -0.230 |
| Other | -0.237 | 0.033 | 0.000 | -0.302 | -0.172 |
| Forestry | -0.374 | 0.077 | 0.000 | -0.525 | -0.222 |
| Stocking Density | 0.477 | 0.037 | 0.000 | 0.405 | 0.550 |
| Labour | 0.080 | 0.036 | 0.027 | 0.009 | 0.150 |
| Age | 0.000 | 0.010 | 0.961 | -0.019 | 0.020 |
| Age squared | -0.000 | 0.000 | 0.627 | -0.000 | 0.000 |
| Agri. Short Course | 0.211 | 0.059 | 0.000 | 0.095 | 0.326 |
| Agri. Certificate | 0.236 | 0.049 | 0.000 | 0.139 | 0.333 |
| Agri. University | 0.057 | 0.121 | 0.637 | -0.180 | 0.293 |
| Off-farm job | -0.011 | 0.050 | 0.828 | -0.088 | 0.109 |
| Medium soil | -0.161 | 0.042 | 0.000 | -0.244 | -0.078 |
| Poor soil | -0.493 | 0.120 | 0.000 | -0.727 | -0.258 |
| Dist_advoff | -0.004 | 0.003 | 0.137 | -0.009 | 0.001 |
| Year | 0.080 | 0.005 | 0.000 | 0.070 | 0.089 |
| Constant | -153.6 | 9.894 | 0.000 | -172.9 | -134.2 |
| n = 3,517 | | | | | |
| Overall $r^2$ = 0.6484 | Between $r^2$ = 0.7713 | Within $r^2$ = 0.1123 | | Rho = 0.4032 | |

*Note: Dependent variable is the log of market gross margin per hectare; years are 2008-2014 inclusive; Border region omitted for collinearity; dairy system omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity*

Evidently, there was a benefit to holding an annual contract with Teagasc over this period in terms of profitability due to the increase in market gross margin per hectare. However, this benefit was reduced as the ratio of clients per adviser increased. All other coefficients are in line with expectations. All farm enterprises show a negative effect against the base case of dairy production which is the most profitable. Stocking density is an important indicator of margin as it relies on efficient use of land. Agricultural education positively affects margin whilst poorer soil shows a negative impact. The distance to the local

advisory office also shows a negative coefficient as expected, albeit not statistically significant. It is also important to consider agricultural price indices over the period under study with a slower fall in input prices particularly in earlier years when the economic crisis began to take hold, followed by similar rises in output prices (CSO 2017). Nonetheless, availing of an annual contract with Teagasc was positive for farm margin.

These findings show the value of quantitative analyses in that the results outline the monetary benefit to KT participation as well as the effect of the consolidation process on these farm level margins. The analysis addresses the research questions that the consolidation did impose a cost that is explained by the increased ratios but that the benefit of participation is confirmed. This is a key advantage of quantitative studies (Johnson and Onwuegbuzie 2004). They provide an easily interpretable indication of the impact of KT during this economically challenging period that can be incorporated to policy discussions for future resource deployment.

**Conclusion**

This analysis measured the impact of KT services at farm level during a period of economic recession when the resources to deliver the services were restrained. By merging two data sets the impact of KT participation on farm level profitability as well as the impact of the organisational consolidation in terms of the increased ratio of clients per adviser could be tested through a random effects model. The results showed that the benefit to participation was positive but the level of impact was negatively affected by the increased ratio of clients per adviser in their local KT office over the period.

There are two main implications of these results. First, the impact of KT participation on farm level profitability is positive which is in line with previous literature (Akobundu et al. 2004; Cawley et al. 2018; Davis et al. 2012; O'Donoghue and Hennessy 2015). The employment of a random effects estimator ensures that these findings are robust in terms of the reliability of the panel data sets and to address endogenous biases that are inherent in this type of analysis. Second, the lower level of resources available for deployment as a result of the economic recession did incur a marginal negative impact, due to the increased number of clients per adviser in local KT offices. This also implies the reverse in that lower client ratios per adviser would have a beneficial impact on farm performance (Prager et al. 2016). This is in line with previous literature that argue a stable or increasing workforce of advisers is necessary to continue to provide up to date efficient advice in a

competent and flexible manner (Garforth et al. 2003; Labarthe and Laurent, 2013a; Sutherland et al. 2013; Swanson and Rajalahti 2010). Accordingly, the client ratio should be considered when decisions are made regarding the deployment of resources to ensure impact in the provision of KT services. In addition, this analysis utilises spatial variables to explain the impact of resource deployment at a local level and outlines practical implications for KT delivery. In this case, a north/south divide emerged that illustrates that the impact of the recession affected KT impact asymmetrically with the northern regions losing more than the southern regions. This is an important implication when considering the public good and access function of public based KT organisations (Kidd et al. 2000).

This study illustrates the merit in conducting quantitative evaluations on impact for agricultural KT providers. By utilising the panel nature of the data set and the random effects estimation method the impact represents the benefit to participation as well as the consequences for resource consolidation in an interpretable and reliable format. However, this analysis could be extended to distinguish between the types of KT participation involved to disentangle what types of KT activity are most impactful. In addition the analysis fails to explain the process of achieving KT impact of the experiences of key informants on how the consolidation was experienced. Qualitative insight could be employed to build on these findings to enrich the analysis by explaining the key factors that affect KT and to build future strategies. A comparative analysis with other KT organisations both public and private during the recession would also complement this analysis further to understand the impact of KT and the deployment of resources in different contexts.

# Chapter 6 - Qualitative Analysis: How Knowledge Transfer Impact Happens at Farm Level

## Introduction

The quantitative analysis presented in chapters 4 and 5 showed a positive impact for knowledge transfer (KT) participation on farm level in terms of profitability and income. This addresses the initial research questions of *what* was the impact of KT on farm level performance. However, to address the final research question requires an explanation of *how* this impact occurs which will enhance our understanding of the key characteristics of the processes and conditions necessary to achieve KT impact. Accordingly, the factors that drive this impact are the focus of this chapter both from the viewpoint of the knowledge provider (adviser) and also the recipient of that knowledge (farmer), and how knowledge is implemented that results in a positive impact. The role of the adviser has evolved in recent times from the traditional consultant and mentor role to include a facilitation role to coordinate group based KT activities (Garforth et al. 2003). Similarly, farmers have become increasingly involved in peer-to-peer learning activities through these participatory group based formats (Läpple et al. 2016). However, evidence on how this evolution was experienced is less common, which warrants further investigation to understand the factors viewed as most effective at driving impact. By uncovering the underpinning processes that explain how KT related impact is driven, these findings will contribute to policy discussions around the types of activities and content that participant's value as effective at improving farm level performance.

The literature shows that providing and explaining the impact of KT at farm level is subject to debate given the complexity of assessing the performance of multi-method activities on a disparate range of outcomes (Anderson and Feder 2004; Läpple and Hennessy 2015). Existing evidence prioritises the delivery of KT services without sufficient attention paid to the recipient of the service and resulting impact on farm level. For example, Kilpatrick and Johns (2003) examined the diverse patterns of how farmers learn, but fell short of explaining how this learning is implemented to improve farm performance. Similarly, Ingram (2008) identified the methods for exchanging knowledge between agronomists and farmers through a partnership based relationship but did not develop on the resulting action taken by farmers nor on the factors that underpin these relationships. Prager et al. (2016) focused on the influence of the increasingly commercial

nature of KT services and how that has impacted on the quality of service being delivered. They found that the sector has become increasingly fragmented with private based KT organisations providing personalised individual consultations for a fee which attracts the more affluent farmers, and public based organisations aiming to serve a more diverse community of farmers who may not achieve the same results. However, in a subsequent paper, they found that this fragmentation can be partially offset though improved linkages and cooperation among actors across both public and private KT (Prager et al. 2017). Again, these analyses focus on impact from the provider viewpoint or the KT exchange, but fail to explain the subsequent action resulting from implementing newly acquired knowledge that ultimately leads to impact. This research addresses this research gap by prioritising the impact achieved at farm level, whilst also examining the complex processes that drive impact. Placing the farm related performance at the centre this research makes a distinct contribution beyond those existing studies listed above. The qualitative approach enables an in-depth analysis that includes both the advisers and farmers to explain how this impact was achieved.

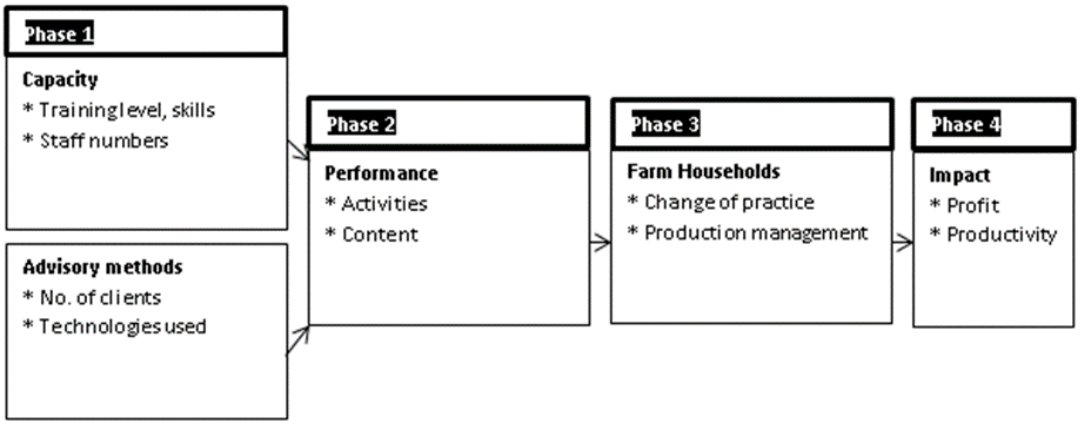
The theoretical discussion in Chapter 2 identified a number of key themes that underpin the process of achieving KT impact that are central to this research question. The motivation of the farmer to participate in the service, the capacity of the provider to deliver the service, the role of both the adviser and farmer, the importance of trust within these relationships, and the process of how knowledge is exchanged, learned and applied are the main themes utilised. Furthermore, by adapting the framework of Birner et al. (2009), this analysis follows an impact pathway which hones the focus of the study. Through qualitative investigation, this chapter enhances our understanding of the effectiveness of KT (Hodge and Midmore 2008), by developing on the key themes that surround each component of the framework. Qualitative analysis enables the researcher to address the '*how'* questions which can be more useful in understanding the social processes that are inherent in achieving impact (Nyanga 2012). In the context of achieving impact achieved on farms in terms of productivity and profitability gains obtained through KT interactions, qualitative research has a practical application in enhancing KT effectiveness by deepening our understanding of the mechanisms and motivations for farmers to apply new knowledge (Macken-Walsh et al. 2012). This is the core objective of this analysis.

This chapter is structured as follows: First, the framework, literature review and research questions are presented, before the sample and methods are described. Finally, the results are presented and their implications discussed.

**Organisational Framework**

This research adapts the framework of Birner et al. (2009) to investigate a pathway of impact from KT participation to farm level performance as discussed in the theoretical discussion in chapter 2. The Birner et al. (2009) model provides an organisational framework that outlines a model to analyse pluralistic KT services that can be adapted to fit the requirements of a specific research question. Specifically, the adapted model outlines selected variables that influence KT impact and the interviews are designed to collect data on these variables. The condensed version of the framework is provided in Figure 11 for clarity:

**Figure 11 Condensed Framework – KT Process**




*Adapted from Birner et al. (2009)*

This research focuses on the capacity and methods for the advisers to deliver the service (Phase 1), followed by the KT interaction performance which involves both advisers and farmers (Phase 2), before focusing on the farmer decision making process to implement new knowledge (Phase 3) and finally the impact achieved as a result of that decision (Phase 4). The capability of advisers to provide KT is mirrored by the absorption and implementation by farmers to examine the process of how impact is achieved. The utilisation of the advice received refers to the extent to which the advice is followed by the user (Bonaccio and Dalal 2006). This forms a crucial part of the decision making process which determines the level of impact achieved.

The adapted version of the Birner et al. (2009) model focuses on the process of KT impact beginning with the ability of the provider to meet the client demand for their service. The means of advisers to up-skill is described as well as the number of advisers in each office. This phase also includes the methodologies available to advisers to deliver the content demanded by clients such as designing the content, activities and utilising technologies. The increasingly participatory format of KT through discussion groups and events in recent decades are central to this functional change (Garforth et al. 2003). This change in ethos involved a rethink on the deployment of resources to achieve impact when designing KT. Advisers determine the content on the basis of both the organisational objectives as well as the demands of the farmer and translate new knowledge into viable formats to trial on farm. The next phase indicated by the arrows is the performance of KT. This is the phase at which the KT content is delivered or 'performed' to clients through a particular activity such as through a discussion groups or a one-to-one consultation.

From these phases, the process of KT impact moves to the farm household where the farmer ultimately decides to implement the new knowledge. For example by adopting a new technology they have learned, or applying a new innovative management practice indicates the implementation of newly acquired knowledge. The adoption of innovative based practices is critical for agricultural development and is a key factor in understanding how farm households operate and remain viable (Morris et al. 2017). The result of this decision to implement is the key focus of the analysis in order to explain the impact achieved at farm level. As the focus of the quantitative analysis was on profitability, this is the primary indicator of impact measured. However, given the link between profitability and productivity it is inevitable that changes in yields is also likely to arise when discussing impact. It is important to stress that these are the key areas of impact focused on in this analysis, although there are many others including environmental and social impacts and complexities within the value chains which as discussed in the Birner et al. (2009) model, but outside the remit of this study.

The model refines the focus of the study to examine the key stages of the KT process to identify a pathway to impact. The pathway illustrates where each aspect of KT occurs and the key themes that underpin these help to explain how KT impact occurs.

**Literature Review**

The literature on KT is comprehensive in terms of organisations and firms, but is somewhat limited in terms of agriculture given the associated complexities of conducting the analysis. Butler et al. (2007) commented on the difficulties of treating 'farms as firms' due to their familial base, multigenerational approach and specific immobile locations. Studies that focus on the farmer side of KT impact are less common and this is a key aim of this research to address this research gap. Nonetheless, several key themes that do emerge from the existing literature include the motivation to participate in the service (Läpple and Hennessy 2015; Lin et al. 2005) the learning that takes place in the knowledge exchange (Aalbers et al. 2013; Coccia 2008; Hansen 2015) the implementation of newly acquired knowledge (Ingram and Morris 2007; Massingham and Massingham 2014; Minbaeva et al. 2003) and importance of trust (De Long and David 2000; Fisher 2013; Ketterings 2014; Swart et al. 2014) throughout the process as well as the respective roles within the process for advisers (Paulin and Suneson 2012) and participating farmers (Legun 2011). Each theme is now discussed in more detail.

*Motivation*

The motivation to participate in KT services is a key methodological concern when considering an evaluation of impact (Nordin and Höjgård 2016). The voluntary nature of participation means that farmers decide to enrol in a KT programme or not based on their perceived benefit (Imbens and Wooldridge 2009), and there is evidence to suggest that these farmers are inherently different (Hennessy and Heanue 2012) with more skilled farmers more likely to participate (Läpple et al. 2013). Moreover, farmers who actively solicit advice are more likely to follow the recommendations of that advice gained through KT interactions (Bonaccio and Dalal 2006). In contrast, farmers may not seek advice due to a lack of interest or readiness to cooperate with others which can be based on internal factors such as a lack of resources or education (Morris et al. 2017). Financial incentives aimed at increasing participation have proven effective, but the resulting impact for those farmers is lower than for those who participate regardless of additional incentives (Läpple and Hennessy 2015). Beyond financial incentives the recognition of a KT service as beneficial given the expertise of advisers and the attached learning is important (Cliffe et al. 2016; Lin et al. 2005). The farmers that participate are likely to be more motivated to learn and implement their newly acquired knowledge, but less is known about the resulting action taken by participating farmers and the influences around

this motivation require further investigation. This research extends on this gap by examining both the initial motivation to participate as well as the motivation to implement the resultant knowledge gained. This deepens our understanding of the influences that affect the commitment to learning new methods and technologies that inevitably determine the level of impact.

*Learning*

Concomitant with the motivation to participate in KT programmes is the desire to learn and improve performance (Minbaeva et al. 2003). Participants require an adequate level of absorptive capacity to retain and use newly learned knowledge (Klerkx and Leeuwis 2008). Learning takes place once new information is combined with existing background knowledge, and upon reflection on the merits of what is learned, action is taken (Bruckmeier and Tovey 2008; Hansen 2015; Torock 2009). However, the learning preferences of farmers are diverse and KT activities are organised to reflect this through the different types (Black 2000). The learning is likely to vary for participants based on their absorptive capacity as well as their preference for learning whether through traditional top-down learning or group based interactions (Coccia 2008). These preferences and different KT activities combine to improve the problem solving skills of participants to achieve better results (Hansen 2015). Within the context of KT services making an impact, the types of activities and content that are most relevant to improving farm performance are not well understood. This analysis bridges this gap by providing evidence on the type of KT activities credited with making an impact by participants in terms of group or individual based formats, as well as the specific content transferred.

*Implementation*

Following the transfer of new knowledge within a KT exchange, impact is dependent on the farmer 'taking action' and implementing what they have learned (Daft and Weick 1984). Quantitative analyses often measure impact in terms of productivity (Hunt et al. 2014; Marsh et al. 2004), or financial performance (Davis et al. 2012; Läpple et al. 2013), whereas qualitative analyses tend to focus on explaining how participants learn within an exchange (Ingram 2008; Kilpatrick and Johns 2003). Furthermore, it is important to distinguish between intent and actual behaviour which may be incompatible in certain cases (Kennedy et al. 2009). To combat this issue the participating farmers were explicitly asked to provide examples of new practices they had implemented as a result of what was

learned in a KT exchange. However, the process of converting newly learned knowledge into taking action on farm is not widely discussed in the literature, although it is acknowledged as a result of a rational decision making process (Ketterings 2014). This decision occurs in the farm household phase of the adapted theoretical model and relies on the acceptance of the new knowledge as beneficial to the farm. The influence of the adviser and peers are both important factors in the utilisation of the KT advice (Ingram and Morris 2007). There is evidence that these influences affect the adoption and accuracy of action taken by participants (Bonaccio and Dalal 2006; Yaniv et al. 2011), but these studies have not been applied in an agricultural context. This analysis aims to contribute to this gap by discussing the factors that motivate farmers to implement new knowledge, and improve understanding on the key influences that drive this decision making process.

*Trust*

A common theme in the literature surrounds the importance of trust in KT exchanges, and that a high level of trust increases the ease of knowledge flow between actors (De Long and David 2000; Hansen 2015). Fisher (2013) argued that a farmer's confidence and trust in the process of KT are critical to convert knowledge into action on farm. This trust refers to trust between the farmers and the organisation (Oreszczyn and Lane 2012), individual trust with farmers and their adviser (Ketterings 2014), and trust among farmers and their peers within group based formats (Hansen 2015), which all depend on a shared understanding of common objectives to achieve impact (Aalbers et al. 2013). This trust is fostered through regular contact and consistent content and service (Fisher 2013). In contrast, poor and inconsistent advice may restrict the ability to achieve impact (Morris et al. 2017), and lower the confidence in the adviser (Van den Ban and Hawkins 1988). The dynamics of these relationships and the evolution of the service pose challenges to this trust. For example, the replacement of advisers, or new members participating in discussion groups or an organisational shift towards innovation based services as opposed to scheme assistance provide additional challenges, and these experiences are not well understood in the existing literature. These nuances are investigated further in the analysis.

These themes are central to the design of the qualitative analysis in that they outline key gaps this analysis can address. The research question stems from these gaps and is outlined below.

*Research Question*

The quantitative analysis demonstrated a positive impact for farmers who participate in KT services, but did not explain how this impact was achieved. The qualitative research develops on these findings by investigating the key factors that lead to this impact in line with the framework discussed above. Accordingly, the main research question is addressed as follows:

1) How is knowledge transferred, absorbed, implemented and then impact achieved at farm level?

This study aims to explore the process of KT to determine the underlying factors that lead to impact. In other words, this research question aims to enhance our understanding of *how* KT makes an impact. This includes the type of KT activities and specific content employed, as well as the respective roles of both advisers and farmers in achieving impact. In particular the role of the adviser has shifted to an increasingly facilitation role for group based KT, and their experience of this shift is discussed. Further the sub-questions that stem from the research question will provide insight into the perceived 'value' placed on the KT service that motivates farmers to participate in KT programmes as well as their learning preferences. Furthermore, the nature of the relationship between the adviser and farmer is queried to examine whether this relationship varies over time, and the importance of trust in the decision to implement knowledge acquired through KT participation. By incorporating the key themes discussed above, this research will highlight the factors that drive impact that can be harnessed for future strategies to achieve continued impact on farm level from KT participation.

**Sample**

The sample focused on informants that were involved in KT related interactions that receive the largest financial impact, namely dairy advisers and farmers in the southern regions of Ireland. Quantitative results consistently show this cohort of farmers as the most profitable farmers in the country, and may be more likely to participate in KT to drive that profit further (Lapple et al. 2016). Theoretical sampling was chosen to recruit informants as this approach relies on the identification of participants who are viewed as particularly suitable to address theoretical considerations through qualitative insight (Bryman 2008; Eisenhardt and Graebner 2007). Although this may cause a bias by not representing the majority of the Irish farming population, it is a pertinent choice to ensure

that the factors that drive impact are explained by targeting informants where impact is most pronounced (Sarantakos 2013). This criterion based sampling approach is strategic in that it draws on insights from sources that are most relevant to the research questions (Bryman 2012; Creswell 2009; Levitt et al. 2018). By focusing on these more progressive farmers, the factors that drive KT impact can be better understood, and in turn can be used to inform strategies to apply to all farms. This approach ensures a thorough correspondence between the core research questions and the sample selected and interviewed (Bryman 2008).

On this basis, clients and advisers assigned to offices located in the southern regions or Ireland were purposively selected after initial piloting with an adviser and farmer in the west of Ireland. Advisers were approached on the basis of their duration of tenure with Teagasc ensuring that all advisers had significant experience to discuss the evolution of the KT service. These advisers were then asked to nominate a client that has held an annual contract over a similar period, and achieved a positive impact from KT engagement. The advisers responded by nominating farmers who they perceived as financially successful farmers who were most likely to implement newly acquired knowledge attained through KT participation. These farmers were labelled as 'progressive', indicating a willingness to utilise extension as a method to learn how to develop their farms (Kilpatrick and Johns 2003). They could be categorised as resource maximisers as defined by Morris et al. (2017), in that they behave proactively and strategically to maximise their efficiency of production. The relationship between the adviser and farmer provided an additional layer to the analysis as all pairs had worked together and established relationships over time as each pairing had worked together for a minimum of 9 years and a maximum of 20 years. These intentionally selected participants have considerable experience of the key concepts being explored (Creswell and Plano Clark 2007), and add to the methodological integrity by addressing the research question through insightful experiences (Levitt et al. 2018).

A total of 5 advisers and 5 Teagasc clients were interviewed (n = 10) from 5 different offices in the southern regions of Ireland where dairy farming is most prominent. The advisers are referred to as AA, AB, AC, AD and AE and the farmers are referred to as FA, FB, FC, FD and FE from here on. The number of interviews is similar to previous studies that focus on farming and given the specificity of the research question and sub questions, data saturation was reached in that no new themes or concepts emanated from the data (Morris et al. 2017). The criterion for selection ensured a consistency in terms of

distinct experiences that provided in-depth information to address the research question (Creswell and Plano Clark 2007). The relationship between each adviser and farmer is now briefly described.

The first paring of AA and FA have worked together for the duration of FA's career, but this relationship is due to expire in the coming years as AA approaches retirement. FA has operated his dairy enterprise for 21 years since inheriting the farm (and adviser) from his father in 1996. The farm is 90 hectares in size with 144 cows (stocking rate of 1.6 livestock units per hectare). AA has worked with Teagasc for 35 years and has been based in the current office for 33 of those years. His workload in terms of the number of clients was 150 clients and this number has not changed much over his career. His area is considered a very productive dairy region with the highest earners and most intensive farmers located in the vicinity. FA is involved in the discussion group Teagasc package which involves participation in a monthly discussion group, access to the adviser for one-to-one consultations, newsletters, invitation to events and scheme assistance duties. The cost of this package varies depending on the scale of the farm as well as the number of additional services received, but the standard cost ranges from €300 to €450.

The relationship between AB and FB was also a lengthy partnership with both the father and son having relied on AB for advice over a period of 16 years. FB refers to the son who has taken full ownership of the farm since the father became ill in 2005, although the father did participate in the interview but the son is the primary farm manager. FB operates on 77 hectares with 145 cows (stocking rate of 1.9). He had recently rented additional land to increase his scale, and admits that he relied on the adviser AB throughout this process as it was a significant financial decision. However, admittedly FB does not implement all the advice he receives from AB through KT exchanges with the E-profit monitor financial tool, a reluctance to outsource machinery work and a difference of opinion on breeding practices as notable omissions. AB has worked with Teagasc for 26 years and operates out of his current office for the past 7 years. The office closures were cited as a particular inconvenience as it has increased his travel time and reliance on phone base consultations significantly to serve his 175 clients. AB and FB also operate in an area associated with intensive production and higher levels of profitability.

In contrast, AC and FC have worked together for just 3 years since AC relocated to their current office full-time in 2014. FC has farmed for the past 20 years and operates a specialist dairy system on 125 hectares with 250 cows (stocking rate of 2.0). Although

FC admits advice received from AC is not necessarily 'gospel', he does implement most of the knowledge he acquires and participates in a discussion group contract which he describes as good value. AC has been a Teagasc adviser since 2006 and operates out of his current office since 2008. However, until 2014 he operated out of 2 offices covering a significant geographic area and over 200 clients. In 2014 an additional adviser was hired to replace AC in his previous office who assumed his clients in that region. He now operates solely from his current office and serves 125 clients. This reduction in clients is in contrast to the majority of advisers who increased their client ratios in recent years as discussed in Chapter 5.

AD and FD have worked together since FD began farming in 2008 and FD admits his demand for advice was more intensive initially but has eased as his experience grew. Similar to FB, FD had taken over the farm due to his father's illness in 2008. Prior to this, FD had studied civil engineering to Bachelor level and utilises these skills to ensure all aspects of the farm operate efficiently. His farm is 90 hectares with 175 cows (stocking rate of 1.9), and he also participates in a discussion group Teagasc contract. In addition, FD also participates in two external private based discussion groups which he also finds valuable. AD has worked with Teagasc for 16 years and is based in his current office for the past 9 years. Although his original office closed in the organisational consolidation, he credits this as more convenient as the new office is located in a smaller urban area in closer proximity to his clients. He serves 175 farmers which also includes approximately 50 drystock clients although he admits the majority of his work is based on serving the dairy farmers.

The final pair AE and FE have worked together for the past 20 years. AE described FE as a progressive farmer commenting that he was always interested in learning and implementing the latest advice. Of all the regions studied the region of AE and FE was described as 'heavier land' indicating poorer quality compared to the other regions where interviews took place. FE has been farming for 31 years and operates on a holding of 119 hectares with 184 cows (stocking rate of 1.5). Like the other participating farmers he holds a discussion group contract with Teagasc and although he is very keen to hear all the latest research and advice he does admit that at times he is slow to implement what he has learned. AE has worked with Teagasc for 20 years and is based in her current office for 6 years. She serves 140 clients, and notes that her number of clients does not vary much year to year, and that many of her farmers are restricted in their ability to increase their scale of production due to the limited land capability.

It is important to note that the advisers selected in the sample had not experienced the rise in clients on average as experienced by advisers elsewhere. AC had reduced his client ratio by relocating and focusing on a smaller area. AA, AB and AE had maintained the same number of clients and area despite relocating office for the latter two. Only AD noted an increase in clients of approximately 20 additional clients since the organisational change, but these were drystock farmers and as such not viewed as a significant increase in workload. The average stocking density for the participating farms was 1.8 livestock units per hectare, which is in line with the national average for dairy farms in Ireland but slightly below the average for the southern region which is 1.9 livestock units per hectare as recorded in the Teagasc NFS. Their primary motivation to renew their contracts with Teagasc was identified as the 'value' received (FD), access to the latest knowledge to learn (FB, FC, FE), and that their annual contract 'frog-leaps' them forward in their expertise (FA), all terms that can be linked to improved performance and profitability. All farmers intended to renew their contracts with Teagasc in the coming year.

**Data Collection and Analysis**

The interviews were conducted over the period May 17 to June 01 in 2017. Interviews were conducted on a face-to-face open ended basis which allowed participants to elicit and develop on their historical recollections as necessary (Creswell 2009). Prior to commencing the interviews all participants were provided with an information sheet on the purpose of the study as well as a letter of consent which was signed before initiating the interview. Both documents are included in the appendix. The interviews were semi-structured in nature in that the interviewer followed a set interview schedule, but the interviewee had ample leeway to develop an issue in their reply. This allowed the interviewer to probe an issue as it arose from the replies which added flexibility to the process and provided additional insight into the thought process of the interviewee (Bryman 2008), as well as addressing the research objective and theoretical considerations (Sarantakos 2013).

On average interviews lasted 44 minutes (range 28 – 58 minutes) with advisers and 28 minutes with farmers (range 24 – 33 minutes). Although the interviewer would have preferred lengthier exchanges with the informants, the interviews occurred during the summer period, which is a particularly busy period for farmers. All adviser interviews took place in their office whereas all farmer interviews took place on their farm.

Interviews were digitally recorded and transcribed verbatim by the interviewer, before being coded for analysis.

*Pilot*

Prior to conducting the interviews, a pilot interview was held with an adviser and a farmer located in the western region or Ireland. Although the pilot did reveal valuable insights into the key themes that were likely to develop, the unstructured nature of the questions posed additional problems for refining the focus of the study. This was the key action adopted from the pilot as the absence of data related to specific KT practices implemented on farms created challenges for coding the analysis. For example, when asked to provide examples of KT that led to a positive impact on farm level, the participants revealed general examples without being specific. Consequently, the redraft of the interview schedule suggested specific KT management practices that are prominent KT services provided by Teagasc to guide responses.

Farmer decision making processes are traditionally refined around innovations in pasture management, animal breeding and the use of management tools among others (Morris et al. 2017). Therefore the practices chosen were grassland management, breeding and financial advice. Grassland management involves a formal management plan for pasture in order to optimise their land efficiency which includes grass measuring, rotational grazing, soil nutrition and reseeding. Although the principles for grassland management are typically presented in a codified knowledge format, the implementation is highly tacit and experiential and specific to each individual farm characteristics. Breeding practices refer to any advice on animal performance through KT advice such as artificial insemination (AI) or bull selection based on the Economic Breeding Index (EBI). Breeding is less reliant on tacit knowledge as these indexes and advice are codified based on an aggregation of key animal traits into a translatable format for transfer. Financial advice refers to specific financial advice related to land purchases or infrastructure projects as well as advice aimed at improving profitability primarily driven by the E-profit monitor system which is a key KT tool that is available to all Teagasc clients. This tool offer insights into the financial performance of each individual farm that can be used for benchmarking and planning. This type of knowledge transfer centres on the trust and motivation of the individual farmer with the tool as well as their relationship with the adviser and the value of the exercise.

Each practice shares the common characteristic of motivating farmers to participate to improve their individual farm level performance through technical productivity improvements due to grassland and breeding management efficiency and therefore improved profitability which requires prudent financial management. However, there are also key differences among these practices which is likely to influence their uptake. For example, grassland management requires farmers to conduct soil analysis, and to measure their grass accurately in order to make improved decisions on which parcels of land to use at certain times. However, this is likely to vary substantially across individual farms which are heterogeneous and each farmer must adopt a unique plan that relies on their tacit knowledge. In contrast, breeding advice is usually simplified into a format where the value of bull selection and stock replacements is provided in the form of a codified index that can interpreted easily by the farmer to guide their decisions. Financial advice relies on the farmer's willingness to engage with an online financial tool to evaluate their individual performance, but is subject to a high level of trust and a competence for understanding in-depth financial information. These differences were investigated in depth as a result of the issues raised in the pilot interview.

The pilot also validated the theoretical sampling approach to focus on farmers in areas where impact related to technical KT content is most pronounced. The pilot indicated that farmers in less favoured regions were more likely to participate in KT for the sole purpose of scheme assistance which does not involve learning or implementing new knowledge on their farm. By focusing on a similar cohort of farmers who are more likely to participate in KT services to improve performance, the data received was richer and more directed to address the research questions. The conversational method of the pilot worked well as both participants could develop on issues as they wished and was retained for the interviews. In short, upon review of the pilot, the sampling approach was more focused, some questions were refined, and the conversational method of interview was retained.

*Interview Schedule*

The interview schedule was designed in a semi-structured format to allow for flexibility in the direction of the response (Bryman 2008). It is important to note that particular questions may not yield the expected evidence (Prager et al. 2017), which can be problematic if the interviewee departs significantly from the topic of interest and runs the risk of an unstandardised data set which is difficult to code (Bryman 2008). However, the benefits of allowing the interviewer to ask probative follow-up questions on unanticipated factors can lead to an enhanced understanding of the subtle factors that explain why an outcome is achieved (Mabry 2008). Accordingly the questions were designed to stimulate conversational answers so the key themes could be extracted from the responses. The semi-structured nature of the questions aimed to induce in depth discussion and aimed to probe at the underpinning factors that lead to impact as per the research question, as well as other forms of impact raised such as the social benefits of networking.

The interview schedule was developed on the basis of two main criteria. First, the key themes that emerged in the literature were adopted to ensure the analysis followed a set pattern to make a distinct contribution to the literature. This included the factors that lead to impact, the roles of both advisers and farmers within KT, the importance of trust for the implementation of learned skills and the challenge of allocating resources to increase impact. Second, the research questions were designed to develop on the limitations of the quantitative findings, namely to explain the factors within the KT process that drive impact.

The interview involved a series of questions that were mirrored for both advisers and farmers, with the exception of their individual roles in augmenting impact from KT participation. Thus, both were asked to provide examples of KT activities that led to an impact on farm level, and to explain the process involved. The activities that were most efficient at achieving impact were probed as well as a discussion on the relevance of the content related to key management practices adapted from the pilot interview. Advisers were asked about the key aspects of KT that drive farm level impact, their role in the process for each activity and how this has evolved in recent times. Specifically, the preparation and delivery of KT was the focus to explain how advisers up-skill, the difference in their roles for individual and group based activities, and the challenges of delivering relevant content to clients. Farmers were questioned on their motivation to participate, the factors that lead to impact on their farm in terms of stimulating learning

through KT activities, their view on the relevance of the content and how they have experienced the evolution of services. Specifically, they were also asked as to their preferences for group formats versus individual consultations, their willingness to implement new knowledge on the specific practices of grassland, breeding and financial management and to evaluate the effectiveness of their participation to achieve a positive impact on their farms. Finally, both advisers and farmers were asked to provide suggestions for further improvements to enhance KT impact. The interview schedule is included in the appendix.

*Method of Analysis*

Once the interviews were conducted, theoretical coding was undertaken which was further synthesised into key themes. The codes were inferred from the theory, and then the data was organised by the adapted framework into segments into of these pre-selected themes (Bryman 2008; Creswell 2009). These themes were then compared to the main themes discussed in the literature and supported with quotations from participants. This approach also allows for unforeseen themes to arise in the course of the interviews through the semi-structured format which supplemented existing themes.

Following Lichtmans' (2013) three C's analysis approach of coding, categorising and developing concepts, themes were drawn in line with those identified in the literature. Lichtman identified a six step process to develop these themes as follows:

1) Initial coding

2) Revisiting initial coding

3) Developing an initial list of categories

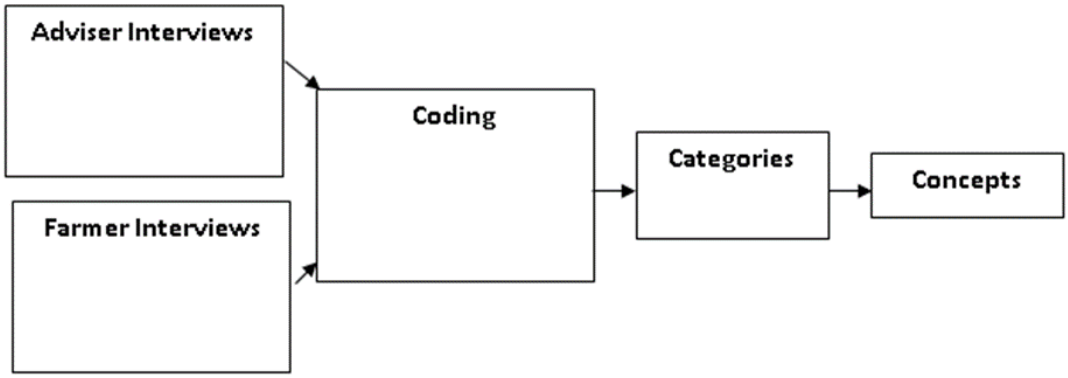
4) Modifying the initial list of categories

5) Revisiting the list of categories/sub categories

6) Moving from categories to concepts

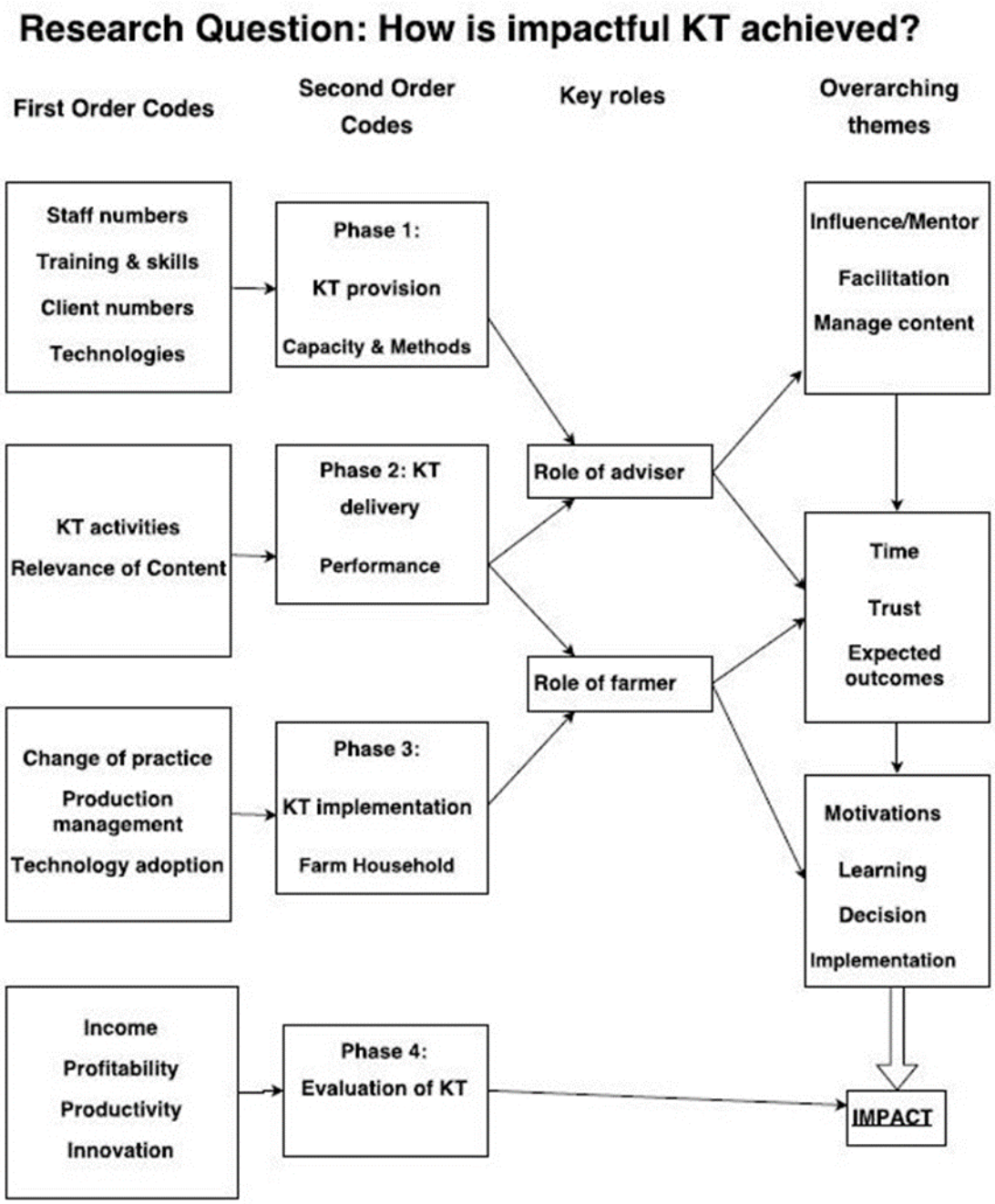
Concepts are then discussed in detail supported by key quotations from the data reflecting the generic approach discussed by Creswell (2009), in which the researcher collects data, conducts thematic analysis and reports on the key themes. The pathway of analysis is illustrated in Figure 12:

**Figure 12 Pathway of Analysis**




The coding approach followed a stepped process following the adaptation of the Birner et al. (2009) framework to categorise the data in a format that captures the pathway to impact from KT participation. The first order codes were derived from the responses and then organised as per the adapted Birner et al. (2009) framework. Next these codes were classified into second order codes by each role and then married with the key themes that emerged in the theoretical discussion to identify the process of KT impact. These themes represent the concepts from the Lichtman's (2013) model but are key in addressing the research question. Figure 13 illustrates the coding approach:

**Figure 13 Coding Approach**




This coding approach is derived from Lichtmans' (2013) method of analysis and organised as per the adapted version of the Birner et al. (2009) model to ensure a coherent and thorough method of analysis. These codes were then developed based on the role of the informants and married with the key themes to explain how impact is achieved. The following section provides the findings of the analysis and key concepts that are developed in the discussion.

These findings are structured on the basis of impact pathway of KT identified in the condensed Birner et al. (2009) model beginning with the capacity and methods in the preparation phase, followed by performance where the knowledge is transferred, and finally the farm household phase to identify evidence of farmer learning and decision making before impact is discussed. The findings are presented in a series of discussions in the format of 'power quotes' in the main text that is supplemented with tables identifying 'proof quotes' to follow the layout suggested by Pratt (2009). This method provides credibility to the analysis by highlighting the main quotations that reinforce the key themes identified, and then supporting these arguments with additional quotations. Power quotes are those where the informant delivers a point concisely that the author could not improve the articulation. Proof quotes on the other hand are used to show the prevalence of that point (Pratt 2009). This approach ensures the key arguments are supported adequately in order to form recommendations based on the findings and ensures a clear presentation style that highlights the key points raised in the analysis.

**Findings**

The central focus of this research is to identify the level of impact achieved on farm level from KT participation and to explain the key factors that drive that impact. This is addressed in depth in the discussion to follow, as all phases of the adapted framework follow a pathway to the KT related impact, in terms of profitability and productivity as described above. The research question of how impact is achieved through KT encompassed all interviews and was developed in line with the framework, but participants also offered a general answer in their replies. For example, AB commented "*if you come back to baseline figures of grass utilised right, you've herd size, animal type, stocking rate, farm management, efficiency, they all ultimately lead to one issue of profitability.*" Similarly, FD noted "*if you listen to the whole thing, the way they [Teagasc] operate their own farms it's all about building condition of the cow, building the grass right, building fertility, building milk solids, it all works together, and if you don't buy into it fully you won't get the results.*" AC commented on the perceived impact received by farmers as follows: *"I think that the fact that they're continuing to do it each year obviously means that they're finding it good. So it's obviously having an impact on it.*" Advisers themselves were able to monitor impact from KT practices implemented on farm through follow up discussions with farmers based around their performance reports. "*We can see that milk solids, fat and protein percentages have risen, so we can track that from the report each year"* (AA). Likewise, AC commented that these reports show

whether a particular management practice 'is actually working' with AB commenting that 'the figures coming off a report are what they are'. These reports are a valuable asset when reviewing the performance of a new initiative introduced through the KT programme. *"The discussion would be on what he should be doing based on the strengths and weaknesses in that report"* (AE). These examples illustrate a positive impact to implementing advice and knowledge acquired through KT interactions. More detailed responses are now discussed in turn.

*Capacity*

The first phase of the KT process is the preparation to deliver the service which is dependent on the capacity in terms of the expertise of advisers as well as the resources available to deliver the service. Birner et al. (2009) defined these variables as both human resources (staff numbers, training, skills and experience) and physical infrastructures (office facilities, demo farms). The capacity of the adviser refers to the knowledge of staff, their ability to translate research findings into farm specific advice and their ability to up-skill through training programmes and networking. The importance of continuous training and up-skilling was confirmed as well as learning from formal and informal structures, namely through organisational colleagues and peers in the wider agriculture and food sector as well as from the farmers themselves.

In-service training is routinely provided by Teagasc to all advisers specific to their specialist enterprise and by topic. These include the latest research findings and practices, information on upcoming events and initiatives, and specialist training for facilitating groups or conducting inspections. This training is typically generic for all advisers. However, AD questioned the suitability for the in-service training to cater for all advisers given the varied levels of experience and that the training could be tweaked to reflect that issue. AB identified both formal and informal sources for up-skilling. "*I suppose there's two sides of it, you've the training coming through at organisational level, you have the structured training, but then you have the I suppose unofficial educated share then that a lot of that is probably coming through colleagues, coming through industries, coming through interaction with private lads."* Apparent here is a view that advisers lean on multiple sources but internally and externally to increase their expertise. The organisational structure of Teagasc that conducts research activities alongside extension and education services within a single organisation (Prager et al. 2014) was identified as an important source of up-skilling by participants. *"The in-service training is brilliant*

*when you get an opportunity to talk to the researchers. And I think that's where you get your up-skilling from"* (AC). The importance of visiting research centres was also raised. FA commented that *"this is where the latest research and studies are discussed so you can see the new information and how things are progressing."*

The skills and experience of advisers was also raised as an important issue. The advisers developed relationships with clients over time that shaped their delivery of the advice. For example, if specific content emerging from research which was not of interest for a particular group of farmers, the adviser could briefly present the results before directing or following as the interaction moves towards more relevant topics. *"I was doing one [discussion group] there recently on once a day calf feeding, and I had it kind of worked out in my head how I wanted to steer the thing but it took a total different tangent like where the farmers got into real specifics such as how much scoops of mix go in the bucket, but it was spot on in that's what the farmers wanted to see"* (AD). This reflects the group based format where the adviser can proactively or in this case reactively facilitate a discussion to generate learning. Similarly AE noted that if a particular topic was not applicable for the group, she would spend ten minutes presenting the findings before moving on to discuss other issues. She explained *"you bring them the information and you spend 10 minutes explaining it, but you know they're not too interested."* The remainder of the group was spent with questions and answers on issues they were interested in.

Nonetheless, the ability of advisers to deliver this knowledge to their audience was critical in terms of KT impact. AB viewed his role as to *"fill the void in terms of trying to pull out the best of the research bits and repackage into something that's workable at farm level."* This refers to research emerging from Teagasc researchers across the research centres. FC also noted this connection between the research staff and advisers in that *"the adviser brings a lot of technical data from research and we'd discuss that [in a discussion group] along with people's personal experiences."* This issue was also raised by other respondents who suggested a mentoring role to persuade farmers on the merits of implementing new knowledge.

The advisers highlighted the issue of confidence in farmers and the need to understand the background of the farm to understand their results. *"You're trying to peel back the layers of why he's not achieving his potential…and you give the guys the confidence that they're doing a damn fine job and maybe just to fine tune it"* (AB). Similarly AC referred

to instilling a confidence in farmers to take difficult decisions and AE referred to the need to provide farmers with the confidence to *"actually do what's been said on paper or on a computer."*

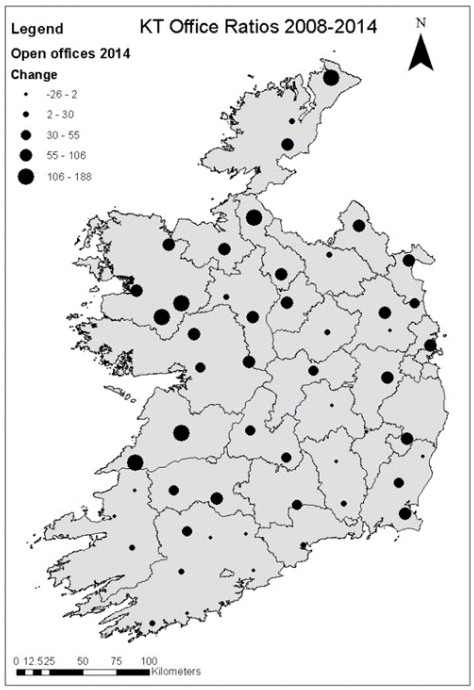
These skills and experience develop over time as relationships are built with farmers, which ensure the advice is relevant to the demands of the farmer which was a recurring issue in the interviews. The relationship between the adviser and farmer was dependent on the level of trust established. *"There has to be a good rapport between the adviser and the farmer, because if the farmer don't trust you, he's not really going to listen to you. So it's getting time to build those relationships is probably key*" (AB). AD estimated this time at *"a few years at the start where maybe they [new advisers] have to earn the farmers confidence and trust*." FC and FE concurred with the latter commenting that "*you build up a professional relationship where you could say anything to her [adviser] and you know it's confidential then as well*." These examples suggest trust may be the most important element of impactful KT, above and beyond activities or content (Ketterings 2014). Additional quotations are also provided in Table 7.

**Table 7. Capacity: Training**

| Informant | Comment |
|---|---|
| AB | You're just trying to develop a network maybe, a network of contacts around the system and just kind of trying to pull the best and the best of the bits out of these lads and try and marry it |
| AC | There's a bit of a discussion that gives them a bit more confidence to make a decision to take out a out a paddock for reseeding or for silage, you know they're more confident doing it. |
| AD | Yeah I suppose it's the in-service training really. Like we have the phone calls there on a Tuesday morning, you'd tune into them and you get the up to date on what's happening, it's pretty much focussed on grass. And then the once a month, we have the in-service training, where we go to wherever the location is and we, you know spend the day and generally talk about whatever's topical at the time and you do, in fairness you'll always pick up a few nuggets at them. |
| AE | *And were you trained in facilitating groups?* Yeah very much so. We trained to to the [maximum] extent that you could be trained |

The other element of capacity refers to the number of advisers available to deliver the service and the context for this is set by the organisational consolidation from 2008-2014. Figure 14 show the office closures and increased ratio of clients due to the reduction in the number of advisers:

**Figure 14 Ratio of Clients per Adviser 2008-2014**




The quantitative analysis presented in Chapter 5 showed that adviser numbers fell by 38 per cent over the period 2008-2014. This increased the client ratios for advisers on average. Despite this, the sampling approach for this study focused on dairy advisers located in more productive regions. As a consequence the sample prioritised participants where the drop in adviser numbers was less severe than in other regions. As AA put it "*we're fairly stable here*." Nonetheless, other advisers (AB & AD) expressed a need for additional advisers to alleviate time pressures on their workload to meet client demand. Commenting on the difficulties of maintaining the service within this context AB commented that "*what's actually carrying the industry is that probably most advisers are working probably beyond in terms of hours, they're probably putting in more graft than they're getting recognition for and that's basically how the thing has been self-sustained."* This implies a certain level of frustration for the additional effort from advisers to continue to deliver the service with reduced resources. In addition, there was a time lag involved in hiring additional advisers in that they needed time to gain the trust

of their farmers. *"There would be a bit of a gap there for a few years at the start where maybe they [new advisers] have to really earn the farmers confidence and trust"* (AD). Similarly AC described his role in introducing the new adviser that replaced him in his previous location as follows: *"Yeah when my replacement took over, I worked with him, I tried to visit as many farms with him as I could before we left. So we didn't just hand over*." This ensured a sense of familiarity with the clients and their new adviser, which is underpinned by trust. It also suggests that increasing capacity will involve a time lag to ensure impact as opposed to an instant solution. Additional quotations are provided in Table 8:

**Table 8. Capacity: Staff Numbers**

| Informant | Comment |
|---|---|
| AA | In years passed we would have lost [advisers], but I suppose in the last 7 or 8 years we haven't. |
| AD | And maybe more advisers might help the situation Yeah |
| FD | But they have scaled up, they've taken a lot more clients on. Now we'll say they have a bigger area to cover then they did 5 years ago, and I suppose that puts pressure on them. Lucky enough if you have an efficient adviser he can handle that but maybe some fellas can't. |

*Advisory Methods*

The number of clients is a key constraint on the abilities of advisers to deliver KT services. All advisers identified a lower level of clients as optimum. AA estimated "*probably 100 clients would be ideal',* with AD stating *'we should be halving the number of clients we deal with…and give them a proper service."* The 'proper' service he referred to was an increased number of on-farm visits (2 or 3 per year) which he credited as more impactful as "*you sit down for 2 and 3 hours at a time and [get into the detail of the issue], but at the moment we're just hopping from a to b to c as quickly as possible."* AA concurred praising the farm visits as beneficial for impact because *"you're out there dealing with farmers and you'll have things to follow up on, and they might ask you questions they wouldn't in a group such as succession or education, but it's just more time consuming."* Both of these quotations reflect a workload issue from the advisers' viewpoint rather than a barrier to impact, which was evident in the farmer responses. Although the farmers did

acknowledge that individual visits were less common in recent times, they viewed the monthly discussion group meetings as more essential and could approach the adviser in that environment for additional personal advice.

Advisory methods also refers to the design of KT exchanges in terms of activity and content and the use of information and communication technologies (ICT) to assist this process (Birner et al. 2009). In relation to the latter, the advisers described the types of media used to disseminate information and advertise upcoming events, although these may be thought of as tools to assist KT as opposed to advisory methods. Nonetheless, ICT is an important enabling technology from which many innovative developments have occurred (Morris et al. 2017), and requires a certain level of skill for advisers to use efficiently. Specifically in relation to these tools, participants responded that their approach has evolved to include ICT. AB stated that *"it's changed the methodology…it's evolving. It's using computer email, phone conferences and whatsapp groups which are add-ons to the system improving things going forward*." AC agreed that advisers must use more ICT to *"get more stuff out."* Advisers also listed several ICT based tools that assist their performance by improved recording systems to deliver reports that can plan and improve farms going forward. However, the use of these technologies depended on the clients with AE describing her clients as "*wouldn't be smart phone people."* FB concurred with this view for some of their colleagues stating *"they don't want anything to do with apps."* In contrast, the importance of mobile phone contact was viewed as essential to conduct individual KT interactions with the advisers, which reduced the need for face-to-face interactions, but also relied on greater flexibility from advisers to respond outside of office hours.

These changes in advisory methods have affected the relationship between the advisers and farmers to an extent. Higher client numbers per adviser have reduced the time available for one-to-one consultations as evident in the above quotes, but the discussion group formats have mitigated this issue somewhat with monthly contact between advisers and groups of farmers. *"You might only get to visit 2 farms in a day but you could meet 15 or 20 in a group"* (AA). The advances in ICT have also relied on the adviser's ability to upskill and adapt to the emerging technologies as well as their increased flexibility in communicating with clients. *"It might be 9 o'clock at night but he [adviser] will get back to you"* (FB). These challenges have relied on the adaptability of advisers to manage the process. AB concurred with this view as he commented that *"what's actually carrying the system is that probably most advisers are working beyond in terms of hours. They're*

*probably putting in more graft then they're getting recognition for and that's basically how the thing [impact] has been sustained."* The advances in ICT have been important in facilitating this process. Additional quotations are provided in Table 9 to support these arguments.

**Table 9. Advisory Methods**

| Informant | Client Numbers & Technologies |
|---|---|
| AC | The numbers of clients should be somewhere around 140, 150. I don't think it should be any more. I think that if you've intensive dairy farmers, that's enough for any adviser to do their job correctly |
| AE | We're using [ICT software] for grass measuring and they [farmers] want help, they might be able to load it up themselves right, but they need help in how to understand it, and how does it make changes on the ground? |
| FA | you'd get which are all now emails out explaining maybe something and you'd get it in the post if we were calculating say, covers of grass or yield per cow and average farm cover per cow. |
| FC | D'you know. This is, we live in the modern times now, I just [call him]. Derogation, I'll just email in all my information. D'you know, instead of meeting 2 or 3 times, we might meet once. |
| FE | It's just easier now on the mobile phone, you get all the information when you want it |

The findings reinforce the importance of capacity and methods in delivering KT services. It suggests that increased capacity would increase the impact of the service, but that there is a time lag involved and impact is likely to be more gradual rather than instant. Additional advisers would alleviate the burden on existing staff and enable more one-to-one KT consultations but these involved a time lag to establish trust. The sources of up-skilling and experience of advisers to work with their clients were key to delivering a relevant KT service. Similarly ICT related tools have become more readily utilised by advisers and farmers in KT exchanges for communication purposes and this trend is likely to continue.

The capacity of the KT organisation to deliver the service is also likely to affect the motivation of farmers to participate. The scale of the organisation was identified as an

incentive for farmers to join. *"They know it's not a one man band…there's a thousand people behind you like…so farmers respect that and that's one of the key selling points we have"* (AD). This is in contrast to the smaller private KT organisations within Ireland that contain few advisers (Prager et al. 2016). The participating farmers outlined their primary motivation to participate as "*access to knowledge"* (FB), "*access to advice, the discussion groups and the latest research"* (FC) and *"access to the Teagasc guy that's over the monitor farms [adviser]"* (FE). The importance of access is key for farmer's to gain from opportunities as they arise (Morris et al. 2017).

In summary, the first phase of the adapted Birner et al. (2009) model focuses on the capacity and methods to deliver KT by the organisation which incentivises the farmer to participate. At this phase the farmers are aware of what KT interactions are on offer in terms of activities and content before opting to participate. These activities and content are discussed in more detail in the following section.

*Performance*

Within the adapted model, performance is the phase where the knowledge transfer takes place through a particular KT activity engagement as opposed to an outcome measure. Performance is defined as the range of indicators that capture the quality of services and can be assessed in terms of the accuracy and relevance of the advice, the quality and structure of the partnerships between participants and efficiency (Birner et al. 2009). It is the phase where the KT interaction is 'performed'. In this study, performance refers to the KT activities as identified by Black (2000) which describes the roles for advisers and farmers within different contexts (individual/group), as well as the relevance of the content delivered on specific management practices (grassland/breeding/financial). The findings related to activities are presented first, followed by the content.

*KT Activities*

The KT activities of interest were the discussion group and one-to-one consultation formats which all participants valued and were necessary to ensure impact. Both were described as complementary to each other (AB, AD, FC) and performed different tasks on the basis of general content such as management principles that were effective in group based environments and more specific private content aimed at individual issues on farms which could also be sensitive. As AE remarked *"it's a specific problem that's solved by one to one",* which was echoed by FB who stated *"I suppose the one to one is probably on a specific, whereas the discussion group can go to anything really."* The consensus around the need for both activity types was noted by all participants to respond to the different needs whether a general overview of a particular management practice or an individual plan that tailored to a specific farm. For example, FD described how a grassland management overview could be provided in a discussion group that shows the steps involved and present results from specific farms. This would then be followed up an individual fertiliser plan based on soil samples taken and drafted into a plan by the adviser to be followed by the farmer. FC concurred stating that the functions were different in that the group formats introduced guidelines on best practice, whilst the one-to-one would be to do with *"contemplating a building project, or land reclamation, or soil sample results. It would be something personal to me."* This complementary nature of both activities is key when considering the deployment of KT resources, but the roles for the participants varies with each.

The role of the adviser varies depending on the type of activity provided, but their ability to influence farmer behaviour is central to KT (Cliffe et al. 2016). AB differentiates his role between both activities as follows; "*well on a one to one, you're probably trying to guide, educate and bring guys along…within a group mentality, you're probably trying to get them to share their knowledge, you probably say an awful lot less."* AE echoed this view describing her role as a 'support' or a 'coach' in the one-to-one activity, whereas in a group based format the adviser facilitates learning through peer interaction. *"In the ideal scenario you're like the referee, you just throw in the ball and they take off with it, whereas in a weaker group you've to do a lot more talking than you should"* (AD). AA agreed *"a good group meeting goes when we have as little input as possible and they discuss away themselves, but in other groups you've more input and try to keep the thing going and tease out issues."* However, the effectiveness of the group depended on the participating farmers and their motivation to interact. FC commented that *"the discussion*

*group is about the people in the group. You can have a great facilitator there but if the boy's just want to meet up and chat, then that's all their going to do."* Similarly, FE echoed this view and highlighted the role of the adviser in that "*she gets the best out of us. She gets the information that we need to tell each other. If we hadn't that maybe we'd go and have a chat about sport."* Evidently the role of the adviser to stir conversation in the group is a valuable skill that has augmented the benefits to discussion group impact. In contrast, on a one-to-one consultation the adviser was expected to intensively participate to *"sit down with a guy"* (AD), *"find out what's going through their heads and try to take them to an end point"* (AB) and *"come back with stuff to follow up on"* (AA).

The ability of the adviser to facilitate learning within the discussion group also depended on the willingness of the participating farmers to engage. FC discussed the process of the group as "*the adviser would bring a lot of the technical data from research and we'd discuss it along with peoples' personal experience and somewhere in the middle we'll find something for somebody."* FD found in his experience that the adviser spent too much time focused on the host farmer in a discussion group meeting and would be better suited to *"ask more question of the group to get more interaction as opposed to just telling the group everything."* In contrast, FB found his adviser was crucial to the success of the group in that "*he creates a discussion or starts a discussion…but in our group it doesn't take much to get the fellas involved."* These examples reflect the shift in responsibilities between group work and individual consultations for advisers, but the facilitation role hinges on the motivation to participate and engage for the farmers. The consensus was that the lower the level of involvement in a discussion group for the adviser, the more impactful the learning and transfer of knowledge for farmers (AA, AB, AD, FC, FD).

However, the willingness of farmers to 'get involved' in discussion appeared to be underpinned by their level of trust developed over time. FA raised this issue of developing trust with peers as he commented *"I suppose when you're the new guy you stand back a bit and listen a lot more to the older fellas and you don't have as big an input because I suppose you're a bit nervous starting off, but as the years go on your progress then like and do share your knowledge more*." AA concurred stating that *"some groups are more easy with each other, they're there longer where they can discuss things way more openly"* (AA). *"The longer you're in a group, obviously you build up a lot of trust, people can trust for their advice about anything I suppose"* (AE). FC and FE insisted there had to be trust in the group as individuals revealed their financial data to each other. *"You get*

*to know these guys and we have a purchasing group going as well so we have a lot of trust in the group…It's like an extended family"* (FA). Once the trust was established farmers could challenge each other more robustly without causing offence, but rather to motivate farmers to improve (FD). "*That's what I prefer now, when I've the group here…I want them to say what's wrong with the place…or why aren't you doing something this way"* (FE).

The ability of each KT activity to achieve a positive impact on farm level divided the participants with advisers identifying the one-to-one as superior and farmers favouring the discussion groups. The advisers argued that an increased number of farm visits would augment the beneficial impact of KT due to more intensive consultations and individual plans. AA argued that the one-to-one *"has the most effective way of making change because you're out there dealing with farmers."* AD concurred *"the one to one visits is where you're going to make the most impact with guys…where you will see the benefit."* AD continued by using soil sampling as an example which is used to develop a plan to improve soil fertility for individual farms and requires individual contact to complete, but lamented the need for additional time to conduct this service.

In contrast the farmers identified the discussion group participation as superior with FB, FC and FE crediting the group interaction as of most benefit to their farm performance. Although the one-to-one was viewed as important and needed to be retained for individual issues as they arose, the group format was viewed as a priority for KT learning and subsequent impact and therefore was necessary more frequently (FB, FC). The discussion group format enabled participants to direct the content towards their interests with FD noting "*some fella might say something that you mightn't have thought of."* Similarly, a discussion group environment offered farmers a chance to view a new practice in action to evaluate its viability. *"I suppose going to see other farmers like and seeing how it's working for them. That'd be one of the big things"* (FB). This quote highlights the importance of the visualization of a particular method or practice to stimulate learning and accelerate subsequent action in terms up adopting a technology or practice. Discussion groups also provided an environment for knowledge sharing which was also credited as a driver of impact. FD stated that *"sharing information at the meetings opens up your eyes to where you are…it will kind of push you to improve your figures."* FE concurred as evident in the following quote; *"Some people don't want to share any information. I'm not mad about people like that. If you want to learn something you have to share the information I think*." However, the extent of sharing appeared to be limited

particularly in relation to sensitive financial information around investment plans which suggests a concern over trust which is discussed in more detail in the discussion. "*If you had bigger plans you might be afraid that some other fella might be chasing the same bit of land…especially in this area where land is scarce"* (FB). It could be argued that whilst financial advice on managing the costs of production is considered a form of KT, individual investment plans is less so.

Upon reflection of these responses, it appears the adviser's viewpoint is driven by concerns over the decreased allocation of time to provide on farm visits. This relates to specific individual issues as opposed to the more general content transferred in a group based format such as guiding principles for technical based management. In contrast the farmers credited participation in the discussion groups as most effective for learning as it provides a *"wide variety of knowledge through interacting with different farmers"* (FA), and a positive atmosphere that *"pushes you to improve"* (FD). This positive atmosphere depended on the participants as well as their trust and appeared to be developed over time and new entrants to the group were sometimes met with caution. FA criticized some of the newer members who joined his group as *"they think they know everything and they don't."* The role of the adviser shifted between both KT activities, but was credited as critical to the functioning of both and associated impact. Additional quotations are provided in Table 10.

**Table 10. Performance: KT Activities**

| Informant | Comment |
|---|---|
| AB | The discussion group model I suppose has been a good bouncer in terms of guys being able to learn from each other and share out these ideas.<br><br>There's some material that can be done and be done quite well in the discussion group format, grassland, breeding a lot of those kinds of things. The general kind of management things. But there's other like, when you get back into nitty gritty of some of individual farm details, they need, basically that needs specific one to one direction. So you know you go from the general to the specific |
| AD | I suppose there are, in a lot of areas especially in the financials there's only so much you can discuss in the meeting, whereas on a one to one you can really delve into what's actually happening there, and obviously they're going to open up an awful lot more to what's happening in the background like. |
| AE | And they [farmers] obviously they see a big benefit from that technical knowledge through the group because they you know have been there for years and years |
| FA | Yeah it is being involved in a discussion group I suppose you get a wide variety of knowledge and you're interacting with other farmers and other advisers |
| FD | On the discussion group side, it's more or less learning off the other fellas. |
| FE | Anytime I've ever had a discussion group I've learned from it like. So I'd say I wouldn't be where I am today now without the actual discussion group |

*KT Content*

Performance also refers to the accuracy and relevance of the content employed in KT interactions to enhance farmer learning and lead to improvements in farm performance (Birner et al. 2009). The content is the KT material that is 'performed' at the particular KT activity. The content of interest refers to technical based advice surrounding grassland and breeding management as well as financial advice. Grassland management and breeding practices which AA referred to as "*the twin towers"* of content were chosen as technical based advice which were supplemented by financial advice through the E-profit monitor tool to refine the focus on the basis of the pilot interviews. These practices are key KT topics prioritised by the organisation to achieve impact. The importance of

relevance and credibility was emphasised in the responses as well as the ease of use in terms of implementing the new knowledge. Each practice is now presented in turn, followed by a more integrated discussion as each topic involves different experiences in terms of utilisation and impact.

*Grassland*

Grassland management advice aims to improve the productivity of land to facilitate stock in an efficient manner. The optimisation of grassland production requires improved utilisation, sward composition, accurate measurement and improved soil fertility (Teagasc 2018). Grassland management advice is provided in relation to soil nutrition and reseeding, maximising the quantity of grazed grass in an animal's diet to reduce costs and achieve high performance, and guidelines on management of pasture during each season (O'Riordan 2011). FD listed the tasks under grassland management as *"measuring grass once a week, using a rotation planner, mapping the place and improving soil fertility."* Teagasc provides guidelines on these practices to increase profitability in terms of a general principle of growing the grass over 3 weeks to graze it in 3 days (Teagasc 2017), and then provide more depth on this principle through more intensive KT interactions. Grassland management advice typically takes place in a discussion group environment where a general overview is provided, and supplemented with an individual plan specific to a farm which may require a one-to-one consultation.

The interviews revealed that grassland measurement practices were not ubiquitously adopted for multiple reasons although the farmers that had adopted them were impressed with the results. Some of the barriers to adoption included the complexity involved in following plans (AB) or the lack of urgency surrounding the uptake (AD). AD expanded that *"the reality is if they don't measure grass they're not going to go broke either. And there's no deadline on it, and it's not a job that has to be done tomorrow, so it'll always be put off."* This suggests a low level of consequence for non-adoption which provides an additional challenge for advisers to 'sell' the practice. Grassland management can be a simple task of walking land and taking stock of the level of grass, but once KT related software tools are added, farmers became more reluctant to engage. AE noted that some clients had difficulty in believing the programme. She commented that *"so the programme says you need to skip two paddocks and it's about having the confidence to actually do it on the ground, to follow what the computer is saying and that's where we come in…Once you get them one field reseeded, it works for itself then and you don't*

*have to sell the message anymore."* This suggests an influential role for the advisers in mentoring and persuading farmers to engage with the practice.

Of the farmers interviewed FB was the only participant who did not follow a formal grassland management plan but did implement an informal plan. "W*e don't grass measure here but, well, we don't do it on paper but we're probably budgeting away the whole time"* (FB). This implies an appreciation for the principles of improving grassland utilisation without committing to the formal requirements of documenting grass levels. FB expanded that *"we don't go out and do a farm walk every week but we'd have a fair idea of what cows are going into or if you're starting to run tight."* This indicates a level of informal monitoring aligns with grassland management principles. In contrast FD fully implemented the advice on grass measuring he received and stated *"it was saving me money. I wasn't topping as much fields. I was getting more value from the grass."* FC concurred and stated that the opportunities and benefits available through grassland management were 'mind blowing'. Following a stepped procedure he commented *"to monitor the grass, to go where the grass is, where the correct grass is, you graze it at the correct time, you graze it to the correct residual, watching your soil nutrition watching your reseeding rate to make sure you're getting enough new ground in",* and through this approach the benefits were *"instant and then there's more after it."*

*Breeding*

Breeding advice includes bull selection for insemination, whether through the use of Artificial Insemination (AI) or a stock bull, as well as planning calving systems and is considered an easier KT topic to deliver due to codified format and ease of use. Breeding advice typically takes place in a discussion group environment where the farmers may ask for additional advice on bull selection from the adviser, but does not require an individualised plan such as the fertiliser plan required for grassland management. In terms of the utilisation of breeding advice, AD described that "*they [farmers] were going to be breeding anyway. So it's only a case of changing what you are doing. Whereas they're not going to do grassland measurement so you're trying to get them to do something that they're not doing."* This reflects the immediate impacts at farm level by implementing breeding practices rather than a more medium term pay off for grassland management practices. AE described farmer attitude to breeding advice as generally positive due to their recognition of stock improvements through the Economic Breeding Index (EBI) which is provided to the farmer. The EBI is a single figure profit index that comprises

information from sub-indexes related to productivity, fertility, calving performance, carcass, maintenance, management and health (Teagasc 2018). Essentially it outlines a monetary value which is related to the breeding performance of the farmer which assists bull selection decisions. The farmers praised the impact of breeding related KT with improving their knowledge related to *"[It shows] certain traits to look for, protein, butter fat and the type of cow I want. Things I knew a small bit about but not enough and frog leaps me [in my knowledge]"* (FA). FB concurred stating his bull selection was based on KT advice "*we probably would have been pushing for bit more yield along with the solids and we definitely see that coming through in the heifers."* This reveals a sense of perceived impact from implementing the knowledge received. FC commented that he would consult with the adviser for breeding advice, but the final decision may differ from the advice received. *"I wouldn't take [the advice from] it as gospel no more than I'd take anybody else's opinion as gospel, but I would value his opinion and take everything on board"* (FC). This shows the adviser is a valued and reputable source and that their opinion is considered prior to making a decision (Yaniv et al. 2011), but independent reason determines the action taken following the KT interaction.

However, the interviews also revealed a level of discontent from the farmers with specific breeding advice related to the cross breeding of dairy cows which divided opinions with FB strongly opposed to this practice and FD and FE in favour. Cross breeding refers to moving away from traditional pedigree Friesen dairy herds to herds that are cross bred with Jersey breeds. The primary argument for this approach is that it increases desirable traits in milk solids which are the beneficial fats and proteins produced, by taking advantage of the hybrid vigour of both breeds while reducing the negative effects of inbreeding (Teagasc 2017). However, a general dislike for cross-breeding for dairy farmers was noted by several participants particularly around their appearance as to *"what colour they are"* (AE), that they just *"don't like the look of them"* (FB) and even that they're perceived as *"a mongrel cow"* (FD). From a KT point of view the main issue of contention referred to the fact that much of the emerging research focuses on the progress of the cross bred herds, despite the majority of Irish dairy farms continuing to opt for pedigree herds rendering this research as of limited value. FB commented that research should involve *"a bit more balance…I don't think they're even 10% [of the national dairy herd]."* AE agreed stating that farmers felt "*like the swing is going this way and [if] I'm not going with it and therefore I'm kind of left out."* In contrast FD and FE openly sought out the latest research on cross breeding, and implemented the approach. This variation

in motivations to implement advice represents a disagreement on the relevance of such advice.

This presents a challenge for KT interactions as the adviser was obliged by the organisation to bring the latest research to their audience, particularly through discussion groups. AE described her role in delivering advice on cross breeding as a brief overview before moving on to other topics of more interest within the group. *"Well I suppose I knew from the offset they'd have no interest in cross breeding, but having said that coming to the breeding time of the season you'd spend ten minutes kind of doing the teaching role just explaining it. And that's it like. We don't go into the whole thing because people haven't moved that way here, apart from the odd fella, but no that's not something we spend time on."* In contrast, FE felt this advice was being 'pushed' on the farmers although he acknowledged that he had implemented the advice and the results were positive. *"It did actually bring up my EBI an awful lot. But that's only through Teagasc that brought that on. I wouldn't have done it otherwise and that information actually showed it's worth doing"* (FE). Again this shows that the reluctance to implement KT advice is a constant challenge, but once the practice is accepted and implemented, it leads to a positive impact. It also reinforces the importance of the role of the adviser in translating research findings into a format that is accepted and viable at farm level. This relates to the issue of relevance of the content as well as a persuasion role for the adviser to convince the audience of the value of implementation.

*Financial*

Financial advice was the third KT related practice examined in the analysis, but differs from the previous content which are more related to technical advice on production. Financial advice refers to any KT content focussed on business performance or investment plans and is typically delivered as a one-to-one KT activity although there is also an annual discussion group meeting dedicated to the topic. One-to-one financially based consultations were often reserved for sensitive investment planning advice or for "*big ticket items"* (AB) such as new buildings or land as opposed to general principles of financial prudence that could be delivered in discussion groups. *"If you're dealing with five year business plans for banks and preparing financial data the obviously you can't do that in a group"* (AC).

For the purpose of this study farmer participation in the E-profit monitor system was the primary focus. The E-profit monitor is an electronic support tool provide by Teagasc, where farmers can enter their financial data and generate a report on their profitability. This service is facilitated by the adviser and provides insights into the efficiency of the farm (AB) as well providing benchmarks to create plans (FC, FD, FE). The E-profit monitor enables farmers to evaluate their performance, which is useful for considering the impact of implementing technical based advice stemming from KT services. Four out of the five participating farmers utilised this tool.

However, in general the uptake of the E-profit has been quite low among farmers and the interviews revealed a number of underlying barriers to engagement which included concerns about confidentiality, credibility and necessity. In relation to the former AD commented "*I still have guys that think the coop [milk processor] shouldn't know how much it's costing them. The information goes into a national database which is available to pretty much every Tom, Dick and Harry, so they don't want to help that system."* This indicates a strategic concern as milk processing companies can use the information derived from the E-profit monitor to restrict the price level to farmers. In other words, if milk processing companies know that farmers can produce milk at a lower cost, then they are more likely to offer a lower price. By refusing to engage with this tool, AD implied that farmers felt increased ownership over their costs of production which can be a useful asset for negotiating milk prices. This is similar to the finding by De Long and Fahey (2000) that showed a lack of trust and loss of ownership on information entered into computer databases and the associated guarantees of its security. AE suggested a privacy concern as she commented *"if I was just to think as an individual myself about giving out information, once you give it to someone you never know where anything goes."* Addressing these concerns is a pertinent issue to encourage greater uptake of financial tools within KT interactions, which will rely on the advisers to demonstrate the impact of the tool as well as reinforcing the security of the data to combat concerns.

The issue of credibility was raised in the context of within group comparisons where *"other farmers can inflate their figures"* (FB). This relates primarily to how labour is measured in that some farmers indicated significant productivity gains without concomitant labour increases which was perceived as unrealistic. This concern centred on the level of labour inputted into the system which is a self-reported estimate of average hours worked per week, with farmers refusing to believe the results. In addition AD and FD also criticised the existing version as failing to take account of loan repayments, taxes

and investments which ensure a superior estimate. This suggests a lack of credibility in the data generated which is likely to reduce the motivation to engage. The issue of necessity also arose in the responses, where farmers appeared to prefer technical based advice. AB suggested that financial advice was a topic better received by younger generation of farmers with FC and FD arguing financial decisions were central to the management of the farm and needed appropriate advice to ensure financial prudence. In contrast, FA commented on the lack of engagement as *"I suppose farmers think they know best in what they're spending or what they're saving but the E-profit is needed for longer term planning."* The use of accountants to manage the finances of farms was also cited by (FB) as a barrier to engage with the E-profit monitor as they already received a detailed overview of their finances without needing this additional tool. These challenges must be overcome to ensure financial KT interactions yield greater impact for participants. Additional supporting evidence is provided in the following Table 11.

**Table 11. Performance: KT Content**

| Informant | Comment |
|---|---|
| Grassland | |
| FC | You go where the grass is, where the correct grass is, you graze it at the correct time, you graze it to the correct residual. Watching your soil nutrition, you're watching your reseeding rate, that you're getting enough new ground in. all of those kind of things. It's mind blowing. |
| FD | We've probably been improving soil fertility here for the last 5 years so again that was through Teagasc as well |
| Breeding | |
| AA | I mean you can, we can see farmers there where their yield per cow might be 350 kilos of milk solids 4 or 5 years ago right. Now we can see they're gone way over 400. And their fat and protein percentages have risen also. |
| FD | Now look, fellas would call it [crossbred cows] a mongrel cow but I don't think, I don't care what the cow looks like if she performs well, it's what's in my pocket as opposed to what I'm looking out on the field I'm interested in. |
| Financial | |
| AD | Then there's other guys that d'you know they're plodding away with their 60 or 70 cows the last number of years, nothing has changed, and they haven't gone broke or anything, they just paddle their own canoe and they like to do things their own way and that's fine if they want to do that. |
| AE | It is, well it is a good thing because you need a, it's a base to measure yourself off of, and how to improve each year and see, you know like. |

This evidence suggests that a combination of activities and the provision of relevant and credible content are key drivers of KT related impact. The discussion groups were preferred by farmers although they did acknowledge the need for individual advice as a specific issue arose, which appeared to be a more valued activity by the advisers. The roles of both advisers and farmers differed in each activity based on the content as discussed. Advisers needed to influence farmers in relation to grassland management due to the complexity of the content and low level of consequence for non-adoption. In

contrast, the advisers explained the EBI which provided a monetary value that farmers could relate to when deciding on breeding practices. Financial advice was more problematic to deliver due to the lower level of interest among farmers more generally, although four of the farmers interviewed did engage and found it useful. The nature of financial advice was also perceived as more of a scheme driven service meaning farmers would only engage when incentivised whereas the merits of participation in grassland and breeding management were driven by a desire to improve productivity and profitability. Nonetheless, content was more readily accepted by farmers in a discussion group format with the visualisation of content and peer to peer learning valued although this was largely dependent on the willingness of group members to share information. As AC described *"once a farmer sees that this works particularly well for a farmer, they appear to take it on board quicker than if we're [advisers] are telling them solely."* Again, this was more of an issue for particular KT content such as grassland and financial than it was for breeding, but the challenge to persuade farmers to implement new knowledge was aided by peer influence. Once this challenge was overcome, all farmers were satisfied with the impact achieved from implementation suggesting that the key barrier to impact lies in the credibility and value of the new knowledge acquired.

*Farm Household*

The farm household is the phase where the farmer decides to implement their newly learned knowledge or not. The role of the farmer in achieving impact is less common in the literature although there are studies on farmer learning (Kilpatrick and Johns 2003), and KT exchange preferences (Ingram 2008) but there is a lack of evidence as to the factors that drive KT impact, including the motivation for farmers to implement what they have learned. Any impact achieved by KT is dependent on the use and uptake of that service by clients (Birner et al. 2009). The decision to implement new knowledge is dependent on the farmers' belief of the validity and relevance of the KT content and in its suitability for implementation on their farm as well as the ease of use. *"I personally would find most of it [knowledge] easy to take it back and trial it anyway. I've trialed things and they haven't been suitable. I've trialed other things and they have been suitable"* (FC). This implies a willingness to implement the knowledge without a guaranteed impact. Whilst individual KT content may not suit all farms, the overall message was of benefit to the farm according to FD. "*But if you listen to the whole thing…it all works together whereas if you don't buy into it fully, you won't get the results out of it"* (FD). The credibility and belief in the applicability of the advice given is key

and the farmers appeared to vary on this issue. The farmer must *"try to decipher from all the information they're getting to make it [KT content] relevant to them"* (AB). This refers to the 'web of influencers' for farmers (Oreszczyn and Lane 2012). To understand this process more clearly, farmers were asked to provide examples of implementing new knowledge gained from KT on their farms both in terms of a change of management practice and/or a change in production.

*Change of Practice*

The decision to introduce a change of practice was dependent on the learning that took place. The group dynamic proved effective for participating farmers, particularly from visiting other farms and a sense of peer pressure to implement the advice received. As FD and FE commented "*it pushes you a bit harder to improve."* The visualisation of a method and the associated impact was particularly important. AC noted that *"you know a farmer is doing something and another farmer sees him and you know that works particularly well with that farmer, they seem to take it up, take it on board quicker."* FB agreed *"I suppose going to see other farmers and seeing how it's working for them, that'd be one of the big things like [about learning]."* AA commented that group interactions were effective as farmers were *"discussing issues and problem solving among themselves…they'll always come away with something."* Peer to peer learning is widely acknowledged in the literature and AD argued that "*it's a lot better because…that's exactly what they want to know."* FD noted *"that the more you can learn from other people the more you can change, benefit your farm*." The consideration of multiple sources of advice can improve the judgment and decision making process of users (Yaniv and Milyavsky 2006). These examples highlight the effectiveness of interactive KT formats that facilitate learning and lead to an increased likelihood of implementation. Further, as discussion groups are hosted on member farms, there was a 'follow-up' element that ensured participants took the action as agreed, ensuring the intent and behaviour were aligned (Kennedy et al. 2009).

The farmers interviewed were described by their advisers as 'progressive' and more likely to implement new knowledge on their farm. However, the responses also implied that this may not be the case for all farmers. FC commented that although he finds it reasonably easy to learn in a KT interaction, *"for a lot of people it's just mental stumbling blocks"* that restrict them from learning and utilising new knowledge. FE and AE also commented on a general reluctance from some farmers to implement new knowledge due to

preconceived opinions on the value with some actions described as a 'waste of time', particularly for grassland management advice. FD expanded by commenting that *"there's probably an hour and a half walking the farm once a week, and a lot of fellas would say that's too long but it's probably the best time ever spent when you do it."* This challenge of persuading farmers to implement this practice is on-going despite the evidence of the benefits presented by the adviser and peers. In addition, a reluctance to implement a new practice based on fear of *"what the neighbour might think"* (AD) referring to farmers walking their land, as well a fear of confirming financial losses through the E-profit monitor (FE) were raised as concerns. Another barrier to implementation raised by the advisers was the associated 'paperwork' attached to a KT initiative in terms of recording and documenting progress. AC commented that "*I think they [farmers] get overwhelmed'* and AE expanding that *'a lot of farmers farm because they like farming animals and driving tractors. They probably never liked figures and this involves figures and writing."* These examples show that motivation to participate is one aspect of leveraging impact from KT engagements but the motivation to implement the knowledge gained is also an important consideration.

AB argued that the key to effective KT was to provide simple information giving an example of a grassland management strategy. FA agreed noting that the knowledge delivered in KT was easy to follow as "*they do explain and go through it slowly and they do it several times*." FB provided an example of his learning experience related to breeding practices commenting that "*where I was starting off, I hadn't a clue what some of the figures meant…but we sat down and went through them and that was one of the most important things for me because from then on we've kind of been focusing on what we're looking for*." The initial learning took place in a discussion group environment followed by a specific breeding plan drafted in conjunction with the adviser on a one-to-one consultation. These examples show a necessity for clear and coherent messages to ensure knowledge is understood and learned in KT interactions, whereas an overreliance on complex information was implied as a significant barrier to absorption by AB, AD and AE. This raises issues around the "*follow through to correct a problem…But once they hear the benefit they're on to run with it*" (AE). The credibility, clarity and replicability of advice is key to facilitate learning. Additional evidence is provided in Table 12.

**Table 12. Farm Household: Change of Practice**

| Informant | Comment |
|---|---|
| AB | The discussion group model I suppose has been a good bouncer in terms of guys being able to learn from each other and share out these ideas. They see where they sit and maybe for the guys that are doing a little bit better, they can try and learn from them as to where they can improve. For the guys that are doing worse, they can see where these lads are making mistakes and avoid those pitfalls. |
| AC | we kind of get them to analyse another group with a different scale and you know it's great and the farmers I think love it because it, you know they can see what another peer in their group is actually achieving with a similar size herd |
| AD | What I find is that you have a few guys who actually went away from farming and maybe went away to college for a while and they come back and they've great attention to detail and everything has to be measured, and they're the best farmers you'll get. Whereas the lad who was brought up on the farm, the father never did it, the son doesn't do it and it's hard to change that mentality and that behaviour. |
| FC | it's interaction with other farmers, it's giving you confidence to go a little tighter, to go closer to what is the ideal instead of staying in the comfort zone. Going to see other people and how they're doing it, that look it can be done |
| FE | You know if you were in an office now and just looking for information you'd probably forget half of it by the time you come out of the office. When you're going around in the group, you kind of learn as you go, and I think you pick up more information. You see what you're learning |

*Change in Production*

The decision to implement a change in production may be more subtle than a change in practice as farmers amend their existing practice based on knowledge acquired through KT. This decision depends on the recognition of the value of implementation rather than a coerced imposition enforced by a policy based regulation. AB commented that "*the problem is if I tell you to take a soil sample because you need to take a soil sample to comply with 3 rules and regulations in terms of nitrates, cross compliance, you see no*

*benefit in the world of doing that.*" The challenge for KT providers is not only to provide the advice, but also to motivate farmers to utilise and implement the advice to ensure impact. FB remarked "*sure you could be giving fellas more advice and information like, but unless they're going to go home and change what they're doing like…made the difference money wise."* AB described these farmers as most likely to implement new knowledge on their farm as "*the lads with a greater appetite, willing and looking for this information. Look at, it makes there life and farm more profitable at the end of the day.*" This type of farmer was also referred to as 'go-getter's' (AE), or 'like-minded, go ahead farmers that drive each other' (FC), which refers to the 'progressive' farmers (Kilpatrick and Johns 2003). However, AD cautioned that some farmers may not implement new practices on farm despite their claims. He explained *"you have the guys in the group who you ask the question and they have the perfect answer every time…and then you go out on to the farm and it's an absolute disaster and they're not doing anything that they're talking about."* AD did admit that the reverse can also occur, *"so you do get it both ways*." This suggests a disconnect between the impression given within the KT exchange and the resulting action or inaction taken, which is in line with the literature (Kennedy et al. 2009). This imbalance between articulation and implementation is a key issue when evaluating the impact of the KT service at farm level.

Taking grassland management as an example, farmers that adopted the advice performed well and lauded the benefits of implementation. However, advisers acknowledged that a lower uptake more generally among farmers was due to the complexity of the content and the absence of immediate consequences for non-adoption in terms of the lag between implementation and impact as previously discussed. The diverse motivations and preferences of farmers were identified as the primary challenge. AD stated that his strategy was that he "*always picked out 4 or 5 lads to focus on, to try and get them to take up the grass and hopefully 1 or 2 might stay at it."* This implies the majority do not implement the advice which FE explained as *"it takes a long time to get farmers to do anything I suppose…some people will say why are you walking around measuring grass it's a waste of time like."* This refers to the practice of physically walking land to estimate the grass covers more accurately which was claimed as "*one of the biggest management changes"* (AB), but time consuming. FD valued this time as noted above to plan efficient grassland management. Again once the value of a practice is recognised farmers were more inclined to implement and these responses suggest a beneficial impact from that decision. The interviews implied that presenting evidence of impact was still insufficient

to persuade all farmers to adopt certain practices and therefore additional incentives to increase uptake are required. Table 13 provides additional supporting quotations.

**Table 13. Farm Household: Production Management**

| Informant | Comment |
|---|---|
| AE | Well I suppose with a long time we're trying to get farmers to grass measure right. And again there's people who, from the first time it was introduced hopped on the bandwagon and went with it and saw the benefits. And there's some and they're listening to it like all those years later and they'll never grass measure, ever. |
| FD | And then in 09, we did the grass measuring here, and that was through the discussion group as well, so I was the monitor farm for the grass measuring that year, and look not many fellas took it on after that, but I've kept it up and I think that's probably a key to us driving profit at the moment.<br><br>If you don't think it's going to work, you're not going to implement it. |

*Additional Issues*

The Birner et al. (2009) model also identified other forms of impact from KT participation that arose in the interviews. The social aspect of the discussion groups was praised by many participants. AE identified the social aspect as beneficial as it provided an opportunity to socialise and discuss issues with peers, which is important given the solitary nature of farming in Ireland. The farmers also outlined the importance of meeting peers experiencing similar challenges with FB stating it was beneficial to mental health. FA echoed these sentiments stating that *"you'd leave less stressful on whatever would be worrying you at that particular time"* after attending a discussion group meeting. This bond developed with participants is central to the 'know-who' element of knowledge transfer as discussed by Ingram and Morris (2007), where a network of colleagues is developed through the discussion groups to overcome issues.

Another form of impact identified by multiple participants was the need to identify methods to ease the burden of labour on farms. This issue is more concerning for dairy producers and particularly for larger dairy farmers due to the high volume of manual

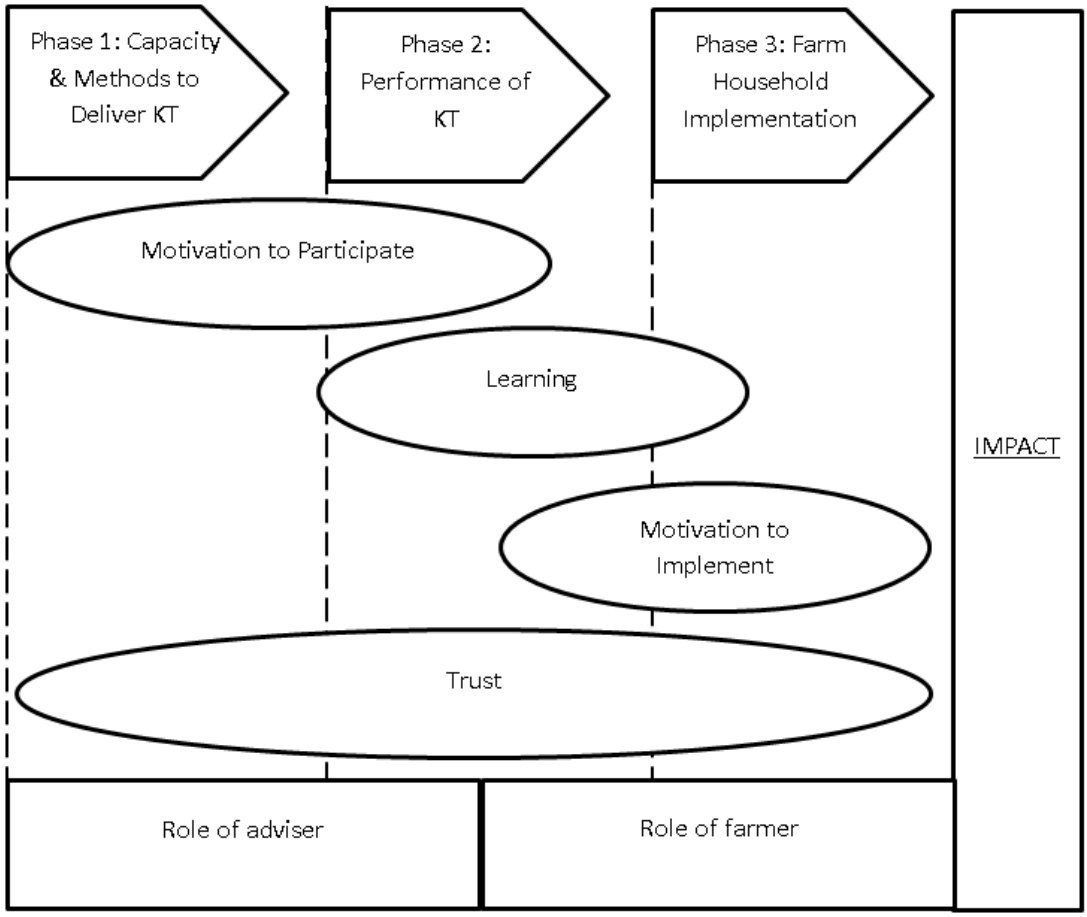
labour required, so it was unsurprising this issue arose in the interviews. AB commented that *"as scale has gone up, labour has become a huge issue"* a point echoed strongly by FB who stated that *"there's only so much you can take."* AD put the question of what an acceptable amount of labour was to his discussion group. The replies were mixed with some farmers stating that working 80 or 90 hour weeks in the spring time was acceptable as they preferred to conduct the tasks personally, but others disagreed and favoured delegation to reduce labour hours. The consensus was that KT content should strive to identify farm management practices to help reduce the burden of labour as per the demand of farmers, although potential solutions were lacking.

Nonetheless, the primary focus of this study is centered on financial impact to maintain consistency and identify a common measure across all farm systems. These findings illustrate the issues that occur at the different phases of the KT process, but to explain how KT impact happens requires a discussion of the underlying factors that affect each phase. This is the purpose of the discussion to follow.

**Discussion**

The interviews sought to address the key question of this research, namely *how* KT impact is achieved at farm level to enhance our understanding of the factors that drive impact. Several authors have acknowledged the complexity of addressing this question given the multiple factors involved (Feder and Anderson 2004; Hagger-Johnson et al. 2013; Läpple and Hennessy 2015). The findings show that the process of KT is underpinned by multiple factors that lead to impact. Impact was achieved through interaction with a skilled adviser and a trusted network of peers, a combination of KT activities, and through relevant and credible content. These factors align with several key themes in the literature and this discussion aims to synthesise this to emphasise the contribution of this analysis. These themes include the motivation of farmers, their learning preference, the implementation of newly acquired knowledge and the importance of trust within each phase of the process. These themes interact with the phases of the adapted Birner et al. (2009) framework as well as including a critical role for both advisers and farmers. The role of the adviser to prepare and deliver the service is contingent on the organisational capacity as well as their accumulated expertise and skills to translate knowledge into interpretable and relevant formats for farmers. The role of the farmer centres on their motivation to participate, their learning and sharing knowledge, and their implementation of newly acquired knowledge at farm level. Figure 15 illustrates this interaction.

**Figure 15 Interaction of KT Impact with Key Themes**




The figure illustrates the complexity of evaluating KT through the multiple of underlying factors that are interrelated in the KT process to achieve impact. The adapted framework organises the process of KT to identify a pathway to impact as listed along the top of the figure. However, the factors that influence this process appear across phases and involve a significant role for the adviser and the farmer to drive impact. The adviser must prepare and deliver the service by translating new knowledge into viable formats for farmers that they deliver in the performance phase. This is dependent on an established level of trust built between both to persuade farmers to implement the knowledge on their farm which occurs in phase 3. The farmer must be motivated to participate which can be incentivised by the KT organisation and individual adviser in terms of presenting the value of participation. The farmer must be willing to learn and support peers in phase 2 and trust that the implementation of the new knowledge will achieve an impact in phase 3. Trust is present in all phases given the relationship between the credibility and relevance of the content. These concepts are now discussed in turn.

*Motivation to Participate*

The motivation of farmers to participate spans phase 1 and phase 2 in Figure 15, that the farmer must be incentivised to participate based on the KT product on offer and then motivated to engage fully in the KT interaction to learn and share knowledge. The findings confirmed that farmers vary in their motivation to participate in KT programmes with advisers commenting that 'regular' clients were likely to continue to participate (AE), from a perceived value in the knowledge gained (AC). These farmers were more likely to participate regardless of additional incentives and utilise the service primarily to improve their farm performance (Läpple and Hennessy 2015). The utilisation of advice acquired through KT interactions is likely to improve the accuracy of decision making for farmers by providing a platform where new information and alternative management practices can be considered (Bonaccio and Dalal 2006). This reflects farmers motivation to improve their codified 'know-what' knowledge as well as their tacit 'know-how' knowledge by interacting with the 'know-who' influencers, namely the adviser and their network of peers (Ingram and Morris 2007). In short, the farmers interviewed participate in KT primarily to improve their knowledge to advance their farm performance.

The different types of KT activity affected the motivation of farmers in different ways, particularly around the specificity of the farmer need. For example, one-to-one consultations were sought when an individual issue arose or for a tailored plan specific to an individual farm. In contrast, discussion group content aimed at more general principles as well as the social peer to peer learning was rated highly by the farmers. However, the interviews also acknowledged that the group format was not suitable for all types of farmers with heterogeneous preferences. Incentives such as financial assistance for participation were suggested to mitigate this issue to increase group based KT (AC), but these incentives do not guarantee implementation of new knowledge or subsequent impact (Läpple and Hennessy 2015). FB acknowledged that financial incentives were an influence on his initial decision to participate in KT but with the exception of 5 or 6 drop outs, the original group members have remained despite the expiration of the financial aid and those farmers were of the most benefit to the group in terms of collaborative learning.

Knowledge sharing within the discussion groups was also raised as a significant barrier to participation, particularly for new members to a group with FA and FB noting that they were more comfortable discussing sensitive issues with colleagues they had built

relationships with. This reinforces the difficulty of sharing sensitive information in a group environment (Garforth et al. 2003) and the need for an established level of trust (Buck and Alwang 2011). FB expanded that he would not have participated in the discussion group if it meant joining an already established group, and as all his group members started simultaneously was a positive factor for his engagement.

These examples confirm that the motivations to participate are complex. Notwithstanding the influence of financial incentives on the decision to participate, the retention of clients is dependent on their perceived value received for their participation in terms of farm level impact. The common goal of group members as well as their interdependence on each other's expertise to facilitate learning was important (Baumann and Bonner 2011), and the role of the adviser was pivotal in facilitating these discussions. Based on these insights, providing evidence of a positive impact from participation as well as recruiting farmers of similar motivations is likely to increase participation further.

*Learning*

The diverse learning preferences of farmers have been commented on in the literature (see Black 2000; Garforth et al. 2003). Figure 15 illustrates that learning takes place for the farmer both within the KT interaction itself as well as through the application of new knowledge on their individual farm. The diverse learning preferences of farmers imply that a 'one size fits all' approach is inappropriate and KT providers have responded by providing different types of KT activities to address this issue. These activities refer to the top-down individual consultation, the bottom up participatory group based formats, mass events and structured courses, although for the purpose of this study the one-to-one consultation and discussion group were prioritised. However, the extent to which each activity is most efficient at yielding an impact is not well understood. The findings revealed a dichotomous view on the effectiveness of the activity type to make an impact with advisers favoring the one-to-one consultation (AA, AD) and farmers suggesting discussion groups as most impactful (FB, FC, FD, FE), reflecting the value in the social learning aspect of KT (Lwoga et al. 2010; Noorderhaven and Harzing 2009). Whilst all interviewees acknowledged the complementary nature of both types to achieve an overall impact, the view on which is most useful divided the participants. Informants acknowledged that some content was inappropriate for discussion in group formats particularly around financial information, although the consensus was that a willingness to share knowledge and data with peers led to additional gains in terms of outcomes and

impact (FC, FD, FE). However, the findings also revealed that the willingness of group members to share knowledge was dependent on the personalities of the participants. Although the group environment fostered bidirectional and horizontal learning (Walker et al. 2009), if the participating farmers were not willing to fully participate and share knowledge it was difficult to facilitate learning in those groups. As a consequence the level of learning within these groups was also largely dependent on the level of trust among members.

The KT activity is an important factor in creating an environment to foster learning for farmers, but in order for learning to take place the absorptive capacity (Klerkx and Leeuwis 2008) and ability to reflect and implement new knowledge (Bruckmeier and Tovey 2008; Hansen 2015; Torock 2009) is critical. The findings developed on this theme both from the viewpoint of learning directly from the adviser (AB, AC) as well as learning from peers (FB, FD). A high level of education was also identified as beneficial for absorbing new knowledge with young farmers who have gained university degrees identified as the 'best farmers' in that they give the best attention to detail and implement new practices as opposed to farmers who imitate what their predecessor had done and often miss out on opportunities (AD). The visualization of a particular practice or technology was credited to increasing the rate of uptake (Cliffe et al. 2016; Hennessy and Heanue 2012). Experiential learning (Ingram and Morris 2007) was also identified as effective for learning based on the observation of a particular practice that was a success on an individual farm (AC, FB). The challenges of learning were highlighted in terms of difficulties farmers have in understanding complex material (AB) and dealing with financial account information (AA).

The link between farmer learning and KT impact is reinforced by these findings, but this is also dependent on the motivation and capability of the farmer as well as the skill at communicating complex knowledge by advisers. The 'one size fits all' approach is unsuitable to facilitate learning in all cases, but the discussion group was praised for learning from multiple sources (Kilpatrick and Johns 2003).

*The Role of the Adviser*

Throughout the process of KT, the impact achieved is relates to the effectiveness of the adviser to translate knowledge into useable formats for farmers, facilitate their learning and motivate the implementation of methods at farm level. Figure 15 illustrates the role

of the adviser spans phase 1 and phase 2 which involves preparing and delivering the content to farmers. However, their influence can only reach the farm gate and the decision to implement is for the farmer alone. Ingram and Morris (2007) found experiential knowledge for the adviser was key that developed over time, but this role has evolved and poses a perpetual challenge of maintaining a relevant skill set. The evolution of the role from the traditional 'top-down' expert to a facilitation role in the participatory KT method is a prime example (Garforth et al. 2003; Ingram 2008). This was evident in the interviews, with an emphasis on performing a dual role to deliver both group and individual based advice. These roles did not appear to cause any significant tension with their roles shifting from one format to the other seamlessly. However, the advisers did note an increased shift towards group based facilitation formats with less time available for one-to-one consultations. Concomitant with these responsibilities was a duty to 'sell' or at least 'influence or persuade' farmers to adopt initiatives. AE and AD commented on the difficulties in imposing a service such as a farm visit or content on an unwilling farmer.

Within the group based format the role of the adviser was to ensure the group actively discussed a particular topic, challenged each other and offered practical solutions to issues as they arose. The ideal group required low levels of input from advisers in the actual KT interaction and more input from the farmers themselves which is the premise for a participatory format. On that basis AA noted that the majority of the input from advisers occurred in the preparation stage, by organising speakers, liaising with the host farmer and developing the content to be discussed such as farmer performance reports. This refers to the relevance of the content as highlighted by AB and AD where certain management principles may not be appropriate for all farm types. AE expanded on this referring to material that farmers were not so receptive towards. Apparent here is a view that some content is necessary for KT events as per the organisation requirements, but the relevance to the farmers may be limited and the discussion shifts towards topics of more interest. This implies a trade-off in terms of the content expected by providers in a KT interaction versus the content demanded by farmers who learn from each other. This is in line with Legun (2011) that found that the farmers themselves were 'knowing agents' with substantial tacit knowledge that could yield additional spillover benefits. This form of 'knowledge in practice' ensures that the direction of the transfer is more dynamic than traditional top down formats stemming from research alone leading to more collaborative learning (Bruckmeier and Tovey 2008; Cliffe et al. 2016).

In contrast, the role of the adviser in a one-to-one consultation related to specific issues as opposed to the general content in a discussion group. This is in line with the literature on the most valued type of KT activity to deliver personalised interpretable knowledge to farmers (Ingram and Morris 2007). Advisers develop individual plans with farmers to improve the performance of their specific farm as opposed to discussing general principles that apply to a wider audience that is more appropriate for group based formats. However, the one-to-one was also acknowledged as more time consuming, and a higher cost due to the individuality of the KT exchange (Black 2000). The findings showed that the one-to-one consultation was not always required by farmers, with FB, FC and FD highlighting that they would only seek an intensive individual consultation with a farm visit from the adviser for a significant project such as acquiring new land, machinery or buildings or in the initial phase of their career when learning the enterprise.

The role of the adviser within both formats was perceived as essential to achieve impact. The skills required to translate new knowledge, develop individual plans and facilitate groups are all key to driving impact. Although the farmers implied that the majority of their learning came from peers and visualising the benefits of adopting a particular practice, they acknowledged that this process would not occur without the facilitation from the adviser. Similarly for individual based advice the adviser was viewed as a valuable asset in terms of assisting farmers with decisions to improve their farm, based on an established level of trust built over time.

*Motivation to Implement New Knowledge – Role of the Farmer*

The delivery of KT services may be predominantly an adviser task, but the role of the farmer to learn and to implement new knowledge to improve their farm is the key consideration when evaluating impact. The farm household phase of the Birner et al. (2009) model is where farmers decide to implement the newly learned knowledge or not, which is represented by Phase 3 in Figure 15. The farmer must rationally weigh up the costs and benefits of implementation and identify it as worthwhile to utilise the advice and implement new knowledge (Bonaccio and Dalal 2006; Butler et al. 2007; Yaniv et al. 2011). The motivation to implement the new knowledge is the key factor that leads to KT impact. FB summed up this point as he stated *"It's what you did at home afterwards that made the difference money wise."* The decision to implement is based on the perceived value of the knowledge learned and practical capabilities of the farm (Ketterings 2014).

The findings also revealed examples of KT based initiatives that were not implemented on farm due to a lack of interest (i.e. cross breeding) or the complexities and lack of urgency of the content (i.e. grassland management). This suggests that farmers do not always follow the KT recommendations by overweighing their own opinion relative to that acquired through KT (Bonaccio and Dalal 2006). However, once the value of the content was accepted as beneficial, farmers were more likely to trial the new knowledge on their farms. This level of acceptance is dependent on the credibility and value of the KT content, and the method to facilitate learning, when both aspects are aligned the farmer appears more likely to implement the practice which ultimately leads to impact. In contrast, if doubts remain over a new practice or method due to its enforcement or a lack of evidence on the expected outcomes, then the uptake is likely to be lower. This disconnect between the value of utilising advice to farm is an important issue to consider when evaluating KT services. FD commented that some farmers struggle with individual bits of advice as unrealistic to achieve on their farms due to additional labour, and yield losses associated with reducing the level of feed to lower costs. The findings imply that significant barriers exist to the implementation of new knowledge on farms and this is a key challenge when trying to achieve KT impact.

The peer pressure effect from discussion group members was identified as a significant motivational factor to implement new knowledge in that group members could challenge each other to achieve maximum results (FD). The openness of farmers to share their data was also viewed as important to invite challenges to their methods, yielding additional benefits. The ability of peers to constructively criticise each other and share knowledge is acknowledged as a key factor in driving effective knowledge transfer (De Long and Fahey 2000; Fisher 2013; Swart et al. 2014). Indeed this peer to peer learning effect is considered invaluable with farmers essentially acting as advisors themselves (Faure et al. 2012), and accessing an average or majority opinion of peers is a major source of influence in decision making (Yaniv et al. 2011). FB also noted a level of competiveness within the groups providing the example of keeping plans secret as a peer may be 'chasing the same piece of land'. This has increasingly become an issue as the dairy herd increased in recent years following the removal of quotas (O'Donoghue and Hennessy 2015), and the availability of land in Ireland is scarce due to a stifled market characterised by low levels of sales, within family transfers and a strong attachment to land (Hennessy and Rehman 2007; Leonard et al. 2017). These examples imply a tension between the openness of farmers to share information and plans with each other and an apparent

reluctance on certain elements. From the participants FB and FE commented that some farmers were reluctant to share sensitive information and this appeared to fuel a general reluctance within the group (FB, FE). However, this differed from group to group based on the personalities within the group that are likely to have diverse preferences and motivations (Vanclay 2004). This point was emphasised by AE, FC and FE in their interviews, but the compatibility of group members was also underpinned by a level of trust established over a period of time (Argote and Ingram 2000).

These findings suggest the challenge of utilising and implementing advice is on-going for achieving KT related impact, as farmers may appear cautious or reluctant to commit to taking action. There is a need to improve understanding of the behavioural factors that influence this decision making process. The findings show that participants recognise a positive impact once the advice is implemented, but acknowledge that this required a visualisation of the benefit, or a significant incentive to adopt or by additional motivation from the adviser. This represents a 'kink' in the KT process and will reduce the level of impact achieved without farmer commitment. The informants in this research overcame this barrier and their results imply evidence of a positive impact which FC described as 'instant'. An enhanced understanding of this motivation would yield additional impacts from KT service participation.

*Trust*

A constant theme raised in all the interviews and fundamental to KT participation, learning, implementation and the associated impact was the level of trust built up over time throughout this process. This trust refers to trust with the organisation, trust with the adviser and trust with peers within a discussion group. The interviews did not explicitly ask about trust but the responses inevitably raised this issue as underpinning all phases of the adapted model as depicted in Figure 15.

The position of Teagasc as the public provider of KT was regarded as an advantage with the unbiased and independent nature of the organisation with no hidden agenda about selling products (AB) and the primary objective to aid farmers (AC) identified as key selling points. The alignment of goals between advisers and farmers is likely to increase the implementation of new knowledge (Bonaccio and Dalal 2006). The public nature of the organisation implies additional objectives such as social well-being and rural development as well as providing value for money for funders. Further these findings

contradict the 'them versus us' mentality that Fisher (2013) found with farmers and government-based representatives and more in line with their trust based relationships with veterinarians. The credibility and trust of the organisation is a key influence in the decision to participate based on the perception of receiving a value out of the service. However, there were also examples of negativity towards Teagasc based on the reputation of the organisation with criticisms in the media (AC) as well as individual criticisms (AE, FD) identified. These attitudes emphasise the need to for advisers to continuously develop relationships with clients to preserve their trust and attract new entrants. Failure to do so could result in a loss of trust which can be difficult to repair (Van den Ban and Hawkins 1988). As Bonaccio and Dalal (2006) found, the utilisation of advice is sensitive to changes in the quality of advice where a good reputation is gained with difficulty, that reputation is easily lost if the quality of advice decreases.

Nonetheless, trust between the farmer and adviser was viewed as essential. Trust in advisers is positively related to advice taking (Bonaccio and Dalal 2006), which implies a higher probability of implementation new knowledge at farm level which directly affects the level of impact achieved. Building relationships with increased learning and knowledge sharing can lead to greater economic impact (Svendsen and Svendsen 2004). The issue of trust arose in all interviews as a key factor in the relationship between advisers and farmers which is common in the literature (Dillon et al. 2018; Fisher 2013; Ketterings 2014). FB commented that if his adviser was to leave Teagasc and set up a private organisation, he'd join him showing the importance of the adviser as a trusted source of KT. Bonaccio and Dalal (2006) argued that recipients were unlikely to take advice if the adviser was not previously known to them which highlights the challenge for newly appointed advisers. However, the trust between both parties must be reciprocal as opposed to blind (Morgan and Murdoch 2000), a point also raised by AC in that the advice received informed his decision but was not necessarily 'gospel'. Advisers benefit from honest communication, and by leveraging the resources within the organisation they can revisit an issue to address a client query (FA). In contrast, providing dishonest advice that could lead to errors is more likely to diminish trust which is challenging to remedy, although there are studies that found that more confident advisers were preferred by clients (Bonaccio and Dalal 2006). The accuracy and impact of KT advice implemented is the key evaluation measure. In the era of technological advancement as well as the multi actors with interests in agriculture the need for advisers to retain and maintain trust and respect with clients is imperative (Oreszczyn and Lane 2012).

The importance of trust within discussion groups was critical to the effectiveness of the group and was found to have built up over time. Raymond (2006) acknowledged that the more individuals interact in a networked environment, the more they learn to trust and cooperate with each other. Hansen (2015) found that learning outcomes increased when a high level of trust was established among members of discussion groups and the ability to challenge each other yielded additional benefits, in line with comments from the interview responses. This form of social capital is instrumental in identifying external sources of knowledge through these networks (Hansen 2015), a point also raised by the advisers in the importance of inviting guest speakers to ensure discussion group content remained relevant. Similarly Sewell et al. (2014) found the importance of developing an honest, objective, mutual trust based relationship with peers and advisers was important to cooperatively identifying solutions to particular problems. FC commented that what was discussed or shared within a Teagasc run discussion group was held in strict confidence and that was a prerequisite for achieving impact. Although farmers did discuss their general financial results with peers within the groups, there appeared to be a threshold they would not cross particularly in relation to information around loan repayments or future plans to expand the size of their farm. There was also a sense of scepticism in terms of trust between farmers in terms of new entrants to the group (FA) as well as a competitive edge on purchasing more land (FB). This reflects a challenge of socialisation where newcomers must learn and integrate with existing group members to achieve acceptance which may take time (Bonaccio and Dalal 2006). However, once the group has been developed over time, and the level of trust among participants is solidified, there is a greater sense of belonging which can be a powerful factor created through interactions, cooperation and common beliefs (McManus et al. 2012). The social benefits of the group were advocated by AE and FB. McManus et al. (2012) concluded that a sense of belonging is a positive attribute of rural communities that contributes to resilience which empowers individuals to continuously overcome challenges. Trust is fundamental to the impact achieved by KT on farm level and occurs at each phase of the KT process.

## Conclusion

The qualitative analysis presented in this chapter expands on existing knowledge by discussing the key underpinning factors that drive KT related impact. Much of the existing literature focuses primarily on quantifying impact, and qualitative studies are more commonly focused on the perspective of the service provider and not on the farm level impact, which is a gap addressed in this research. In addition this Chapter outlined

an adapted framework to identify a pathway of impact that illustrates where each phase of KT occurs and then interacts this framework with the key themes to explain how impact occurs. The semi-structured nature of the interviews with key informants involved in the most impactful KT exchanges enabled a discussion to address the research question.

Impact was achieved through a combination of KT activities and focused on relevant and user friendly content to stimulate farmer learning and motivate their decision to implement. These principles were strongly underpinned by accumulated trust between the organisation and farmers, advisers and farmers and farmers among themselves. Furthermore, the role of the adviser has evolved in a dual function of both a source of expertise and also a facilitator to draw out tacit knowledge from farmers in a group. The role of the farmer was also investigated with an emphasis on the implementation of newly acquired knowledge to achieve gains in profitability.

These findings raise several implications. First, it reinforces the need to ensure that public KT providers have adequate capacity to deploy resources efficiently to serve clients. Advisers acknowledged their level of training and skills to translate knowledge to a viable format for farmers but did stress the intensity of serving so many clients. In contrast, the farmers were satisfied with the value of their KT interactions, with an emphasis on the impact and learning that takes place within a discussion group, and that access to the adviser was critical for individual based advice, which also represents a capacity based issue. Second, the findings confirm that a 'one size fits all' approach to KT is inappropriate given the heterogeneous preferences of farmers (Garforth et al. 2003; Vanclay 2004). Both formats are complementary but the value of the discussion group was perceived as higher to participants despite the concerns of the advisers. The relevance and flexibility of the content delivered in KT must be adapted to the demands of the farmer, particularly in discussion groups. An increased role in KT design for farmers would benefit the design of this content (Faure et al. 2012). Thirdly, the motivation of farmers to implement new knowledge is not well understood. The findings revealed that the visualisation of a practice along with a peer pressure effect and the compatibility with their farm were influential factors in increasing the uptake of a particular practice or method, but significant barriers remain particularly for practices that do not yield short term impacts. Finally, the importance of trust was key to ensuring KT related impact and this depends on the reputation and familiarity of the organisation, the individual adviser and the other farmers within group formats. The dilution of this trust was a key risk to

KT participation, and the absence of trust will lower the impact achieved through KT by reducing the motivation to participate.

These findings provide additional insights to the relationships identified in the quantitative analysis providing a balance to this research. The qualitative approach enabled an in-depth investigation of the key factors that drive KT related impact. However, given the purposive sample the respondents may not reflect the majority of Irish farmers, and an increased sample size would enrich these results further. The link between each analysis is discussed in the final chapter to clearly identify the contribution of this analysis.

# Chapter 7 – Discussion and Conclusion

## Introduction

This chapter provides a summary of the main findings of this research and a discussion on the implications of these to establish the contribution of this study. Agricultural knowledge transfer (KT) services provided by public extension organisations are a key policy instrument to influence farmer behaviours to achieve desired objectives. Accordingly, the evaluation of KT impact at the farm level was the key objective of this study. This refers to both quantifying *what* the level of impact was as well as explaining *how* this impact was achieved through a multi-methods analysis. The findings make a significant contribution to the literature in both the economic and management disciplines by providing an economic assessment of KT related impact and explaining the underpinning factors that drive this impact.

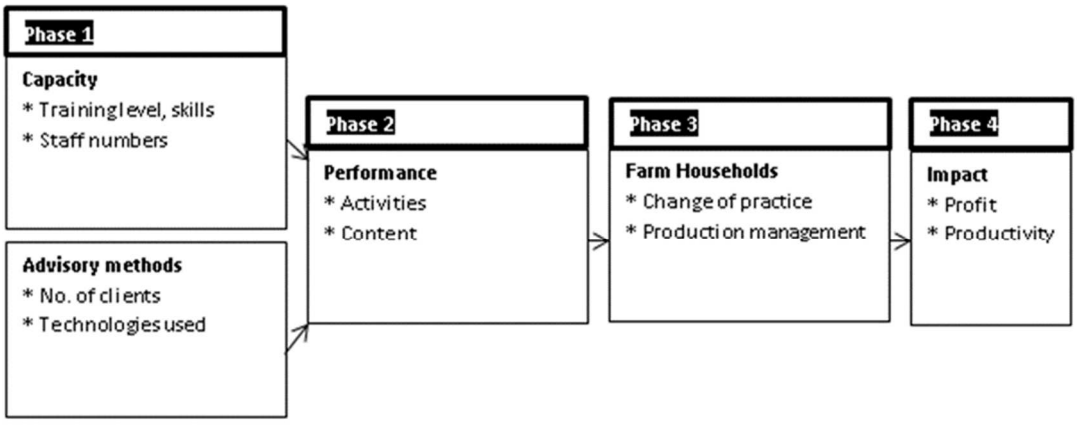
This chapter reintroduces the theoretical framework applied in the analysis, as well as summarising the main findings and implications for the study. The contribution of these findings is discussed in detail before recommendations, caveats and suggestions for future research are presented.

## Contribution and Implications

The overall aim of this research was to evaluate the impact of KT on farm level performance in terms of measuring the level and increasing our understanding of the process that leads to the impact. This research presented a multi-methods analysis on the impact of public KT services on farm level performance in Ireland, by quantifying the level of impact over time, and qualitatively exploring the underlying factors that led to this impact. Evaluating the impact of KT is challenging given the pluralistic objectives of providers, the voluntary nature of participation, the variety of methodological options and the broad range of possible outcomes (Läpple and Hennessy 2015). A range of confounding factors can also influence impact such as the policy environment, asymmetrical access to participate or unobserved farmer characteristics. Theoretical considerations must also be addressed such as defining knowledge as a resource and highlighting the challenge of its transfer, as well as explicitly identifying the interpretation of impact which were addressed prior to conducting the analyses.

To overcome these challenges, a theoretical framework was adapted from the Birner et al. (2009) framework to identify a pathway to impact in the KT process and refine the focus of the study. This simplified version of the Birner et al. (2009) framework aided the design of the study to address the research questions. Notwithstanding the wide range of other factors that influence KT performance and the resulting impact as well as the dynamic process that includes feedback loops, the condensed version provides a framework appropriate to this study. Profitability was the main impact of interest as well as productivity which are both closely aligned. These measures were chosen on the basis of their relevance to all farm enterprise types. The adapted framework is presented in Figure 16:

**Figure 16 Condensed Framework – KT Process**




*Adapted from Birner et al. (2009)*

This condensed framework focuses on specific variables to identify a pathway to impact from KT that initiates with the capacity and methods of the KT organisation and adviser to deliver the service. Next the KT process moves to the performance phase where the KT interaction is carried out through a particular activity on specific content. The third phase focuses on the farm household where the farmer decides whether to utilise the advice and implement the new knowledge or not. Finally impact is achieved and for the purpose of this study is defined as the resulting change in farm level profitability and productivity. A multi-method analysis was chosen on the basis of providing quantitative evidence of impact that is further developed through qualitative insight into how the impact is achieved (Faure et al. 2012).

*Quantitative Analysis*

The quantitative component of this study provided a measure of impact for KT participation on farm level income and farm level profitability differentiated on the inclusion or exclusion of subsidies. This distinction was made on the basis of including all participating farmers across all enterprise types regardless of their primary motivation to participate followed by a more refined measure of profitability to reflect the impact attributed to more technical based KT interactions. The Teagasc National Farm Survey (NFS) was the main data source used to measure impact at farm level, which is a panel data set of approximately 1,000 farms per annum and collects farm level data on performance in terms of output, revenue and costs across a range of systems, sizes and profiles nationwide (Connolly et al. 2010).

A central challenge to these evaluations is to combat statistical endogeneity caused by self-selection biases, omitted variables biases and measurement errors. The quantitative analysis overcomes this challenge by applying sophisticated econometric techniques to estimate impact. In the first quantitative study, the impact of KT participation was evaluated using an instrumental variable (IV) approach which provides a superior measure of impact (Murray 2006). This analysis relied on the identification of suitable instruments to purge the endogeneity from advisory participation. The distance to local advisory office and the introduction of a policy change were found as appropriate for this task. The results from the IV analysis showed that KT participation resulted in a 35 per cent increase in family farm income per hectare over the period 2000-2013. The dependent variable of farm income included subsidies as these are a substantial component of income, particularly for beef and sheep enterprises, but also as a considerable number of participants interacted with KT for scheme assistance duties only. This result implied Ordinary Least Squares (OLS) estimation underestimated the impact of participation which is in line with previous literature (Card 1993; Cawley and Meyerhoefer 2012). This showed a positive impact on farm income for participating in KT programmes, which in turn should incentivise more participation among potential KT clients. The value of KT services as a policy tool should be promoted further to incentivise further engagement that can be leveraged to achieve policy goals such as to increase economic competitiveness through productivity gains. A more targeted approach to incentivise more intensive engagement may be valuable to achieve these goals (Akobundu et al. 2004), but this analysis reinforces the importance of a public KT organisation in its role to achieve an impact on farm level for participating farmers.

This study also demonstrated the value in applying an IV estimation approach when suitable instruments are identified. The IV method is not common in the literature given that challenge of identifying suitable instruments. However, this analysis overcame this challenge by incorporating the distance to local office and an exogenous policy change which affects participants and non-participants alike. These instruments were both relevant and valid in this analysis and could create opportunities for future research to estimate superior measures of impact. These instruments combatted the endogeneity from the analysis by identifying factors that affect the decision to participate in KT without directly affecting the dependent variable of farm income. This enables a superior measure of impact, and further studies could adopt similar instruments to evaluate impact for more robust findings.

The ability of a KT provider to deliver this service, however, is based on the level of resources available which dictates the capacity and methods to perform KT, and the organisation of interest in this study, Teagasc, experienced a period of significant organisational consolidation due to the economic recession from 2008. This reduced the level of resources available to deploy the KT service with significant office closures and reductions in the number of advisers which increased the ratio of clients for retained advisers as client numbers remained relatively stable over the period. The second quantitative analysis refined the focus of the evaluation to focus on this period of organisational consolidation to measure the continued impact of KT participation on farm level performance.

The IV approach was also considered for this analysis but in the absence of a suitable instrument the methodology was diverted to utilise a random effects estimator which is an alternative that takes advantage of the panel nature of the data set utilised (Gujarati 2003). Two datasets were merged to conduct the analysis. The first was the Teagasc NFS to reflect farm level outcome indicators and the second was administrative data to reflect the organisational consolidation stemming from the economic recession in terms of office closures and staff reductions. This analysis removed subsidies from the measure of impact to focus on the profitability of the farm which was a more refined measure of impact.

The analysis also showed a positive impact of 12.3 per cent for KT participation on farm level margins over the period 2008-2014. However, the consolidation of resources negatively affected this impact as the ratio of clients per adviser increased. Each additional client assigned to the retained advisers reduced the level of impact at a rate of

0.2 per cent per client on average, which in total was a negative impact of 9.6 per cent. The scale of this decrease varied spatially with the north western regions of Ireland more affected than the south east with higher ratios more common in the former. The improved economic conditions since 2014 have seen the recruitment of advisers recommence, implying that impacts could be improved further. This was one of the key implications from this analysis as a positive impact was maintained despite the challenge of the consolidation and the results indicate that the reversal is the case as ratios of clients per adviser are reduced. The second main implication from the analysis is that the spatial deployment of resources for KT provision is a key consideration to achieve ubiquitous impact. The consolidation led to asymmetrical impacts for participants and given the public nature of the KT provider in the study, there is a responsibility to provide access to all potential clients (Kidd et al. 2000).

In summary, the quantitative findings found a beneficial impact for KT participation but an investigation of the process that led to this impact would enrich the analysis. This was the primary rationale for conducting the qualitative research to explore the underlying factors that drove the impact from KT participation.

*Qualitative Analysis*

The qualitative analysis developed on the gaps of the quantitative by addressing the research question of *how* KT impact occurs. Many of the existing studies focus on the role of the adviser and their ability to deliver the KT service efficiently to achieve an impact but this analysis also included the farmer in this process and specifically their motivations and preferences in the KT process.

A sample of advisers and farmers was purposefully selected to address the research question on the basis of two criteria. Firstly that they were involved in dairy KT which is the most profitable enterprise located in more productive land areas. Secondly, informants must have participated in KT for a significant period of time to provide insights into the evolution of the service. After initial piloting, semi-structured interviews were conducted with 5 advisers and 5 farmers located in 5 different locations recognised as profitable dairy regions. The analysis was conducted following Lichtman's (2013) approach and theoretically coded as per the adapted Birner et al. (2009) framework.

Several of the key themes identified in the theoretical discussion were apparent in the interviews, namely the motivation of farmers, their learning preferences, the respective

roles of the adviser and farmer and the importance of trust throughout the KT process. The findings showed that KT impact was achieved through interaction with a skilled adviser and a trusted network of peers, through a variety of KT activities, and through relevant and credible content. The role of the adviser was acknowledged as multifaceted with their traditional role as a top-down leader operated in tandem with facilitating groups to deliver KT. All participating farmers were motivated to participate with Teagasc due to their perceived value of that participation and that Teagasc was viewed as a trustworthy organisation to serve their interests without trying to 'sell' or 'push' an agenda.

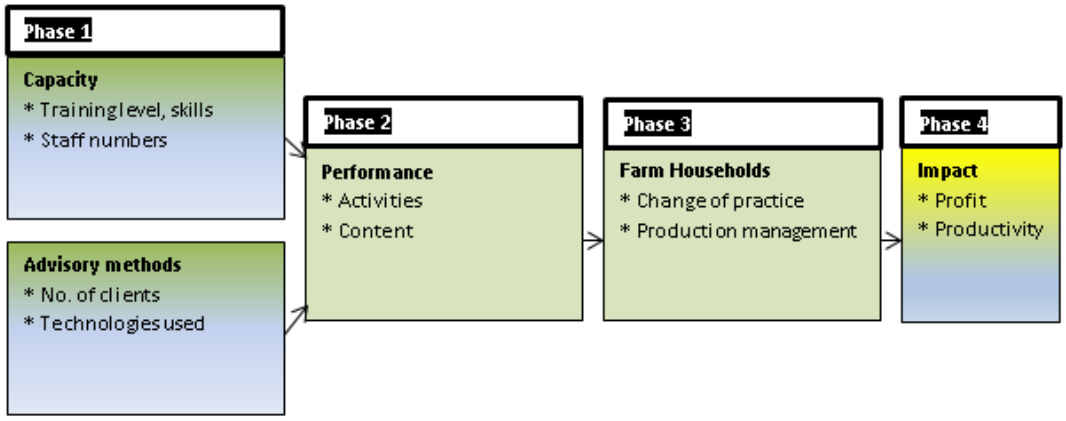
The qualitative analysis contributes to the literature in a number of ways. Firstly, the adapted framework provides a method to organise and code qualitative data to address this research question. The capacity of the KT organisation to deliver the service is key in equipping advisers with the necessary skills to communicate complex material to clients. This is also likely to influence potential farmers to participate, who demand access to relevant and credible content across multiple activity formats facilitated by a trusted and competent adviser. The preferred activity for informants varied between advisers and farmers with advisers identifying one-to-one consultations as most impactful but farmers choosing the discussion group format. This contrast implies that there may be opportunities to prioritise the participatory group methods in the deployment of resources with additional opportunities to liaise with the adviser at these meetings. However, as some farmers are unlikely to participate in these formats the one-to-one consultation and individual on-farm visits are also important to retain, albeit as a lower priority than previously anticipated. Nonetheless, involving farmers in the design of KT services is likely to incentivise further participation reflecting the bottom-up approach as advocated by Black (2000). In addition, the motivations for farmers are not well understood in the literature, particularly for their motivation to implement newly acquired knowledge on farm. This analysis showed that the visualisation of a practice, supported by the adviser and through peer influence were key motivational factors, but the lag between implementation and impact remains a challenge. This suggests that the KT content must be supported by clear evidence with guiding principles that can be adapted on individual farms, and the farmers appear more likely to learn and implement following a group based presentation of the practice. Given that this sample prioritised the more profitable farmers in dairy enterprises, it would enrich this analysis further to also investigate other cohorts of farmers to identify their preferences and motivations. The importance of trust was also a key finding in this analysis with trust between the farmers and the organisation, the

individual adviser and among their peers as a prerequisite to the impact of KT. The maintenance and enhancement of this trust remains a key motivational factor for participating farmers to continue to engage and implement new knowledge on their farm.

*Overall Contribution*

For completion the condensed framework is provided again in Figure 17 to illustrate the contribution of each analysis and to clarify precisely where each contribution was made:

**Figure 17 Condensed Framework – KT process**




*Adapted from Birner et al. (2009)*

The first quantitative analysis evaluated the impact of KT participation on farm level income. This contribution primarily focused on the impact phase of the model as illustrated by the yellow colouring in Figure 17. The second quantitative contribution again focused on financial impact, but prioritised impact on profitability by excluding subsidies from the dependent variable. Furthermore, this contribution utilised a unique period of organisational consolidation with consequential constraints on capacity and methods to deliver the service. This analysis found that KT participation increased farm level profitability but the level of impact was diminished by each additional client accommodated by advisers over the period. The focus of this analysis is shown in the model by the blue colouring which is combined with the yellow for the impact phase give their dual function of evaluation. The qualitative analysis focuses primarily on the first, second and third phase of the framework as illustrated by the green colouring. The capacity and methods to provide KT services as well as the performance of the KT activity based on relevant content and ultimately the decision of farmers to implement the new knowledge at the farm household which all lead to impact in phase 4.

The three contributions of this study offer a valuable contribution to the literature when considered simultaneously. The research questions aimed to investigate *what* was the level of impact achieved at farm level for participation in KT services, and also *how* this impact was achieved. The findings showed a positive impact for KT participation, although the level of this impact was confounded by the need to efficiently deploy resources as well as the key roles of both farmers and advisers in a process underpinned by trust. The initial analysis found that on average participating farmers received a positive impact on farm income from participation regardless of the intensity or purpose of their interaction. The organisational consolidation driven by the economic recession created difficulties in maintaining KT impact on farm profitability. However, the analyses showed that on average participants continued to receive a positive impact, and qualitative insights explained that the flexibility of the adviser in terms of communication and an increased emphasis on group based formats helped to facilitate this impact. Furthermore, the role of the farmers in learning and implementing their newly acquired knowledge were identified as key enabling factors for KT impact and therefore an increased emphasis on participatory designs for KT could increase this impact further. The value of utilising the advice is more likely to be accepted when the knowledge is relevant and can be tailored to the practical capabilities of the individual farm (Butler et al. 2007; Ketterings 2014). Nonetheless, the value of knowledge as a resource as distinct from data and information was reinforced by the analysis as a driver of motivation for farmers to participate. The informants recognised the benefit from KT interactions as developing their knowledge more so than simply providing access to information (De Long and Fahey 2000), and the KT process facilitated this transfer. The distinction of knowledge into the typologies of 'know-what' and 'know-how' (Ingram and Morris 2007) are critical in this regard as the former can be delivered as a codified set of principles but the latter relies on the tacit knowledge of the farmer as well as their preferences when implementing new knowledge.

The qualitative analysis also identified a division between advisers and farmers in terms of the key activities that drive KT impact with advisers citing the one-to-one consultations and farmers preferring the discussion group model. This highlighted a difference in the perception of each KT activity with the facilitation role valued highly by participating farmers to enable peer-to-peer learning, whereas the advisers themselves perceived the individual mentoring role as more impactful. Encouraging more participation for farmers in KT design could resolve this issue given the role of farmers as the 'end users' of the

knowledge and therefore could identify the content and activities of most relevance. Similarly, the content itself was identified as a point of contention with particular topics such as the value of grassland management, undesired breeding advice and sensitive financial advice identified as valuable advice by the informants, but in need of further persuasion to encourage wider participation and acceptance from other farmers. These differences in perception of KT activities and content imply there are opportunities for greater integration within the KT process to co-develop programmes most suited to achieving impact and therefore achieve desired policy objectives. This would improve on the 'know-why' and 'know-who' knowledge typologies as advocated by Ingram and Morris (2007), as farmers, advisers and policy makers alike co-design KT content to achieve a desired impact. This was particularly relevant to discussion group activities where the farmers preferred to direct the content towards their interest rather than the results of research viewed as irrelevant. To examine the feedback loops in more detail, and to examine the communication channel between the advisers to the researchers within Teagasc would be a useful addition to the analysis.

The multi-methods approach adopted in this study ensured a robust analysis that could be harnessed further for evaluations more generally. Each method in isolation can only partially address an evaluation of impact with quantitative analysis more desirable for stakeholders on an accountability front to secure funding, and societal impact often captured through the experiential learning that takes place in the process. This study applied both quantitative and qualitative methodologies in order to achieve a more accurate and more valid analysis, through complementary insights to deepen the overall understanding of KT impact despite the inevitable epistemological conflicts (Hamade et al. 2015). Accordingly, the quantitative analysis prioritised estimating a measure of *what* the impact of KT participation was, while combatting endogeneity biases, and the qualitative focussed on the KT process and enabling factors that drive impact to explain *how* KT impact is achieved.

The quantitative analyses align on the beneficial impact of KT activities on farm level income and profitability, whilst also raising the issue of the importance of efficient resource deployment. The qualitative develops on this by examining the KT process from the preparation and delivery of KT to the resulting impact of action taken based on the newly acquired knowledge. The qualitative provided insight on how the KT resource consolidation was experienced by participants and how the advisers managed this process to continue to deliver the service. The qualitative also examined the types of KT content

and activities that drove impact, which was not possible to distinguish in the quantitative analyses. Conversely, the qualitative sample prioritised the most progressive farmers, whereas the quantitative provided a measure of impact for a wider population which may be of more value to policy makers. The employment of both approaches were complementary and necessary to explain the impact of KT. As the number of evaluations continue to increase in the literature as their value in identifying factors that achieve impact and those that do not (Faure et al. 2012; Norton et al. 2016). The methodology applied in this study can be a useful addition to the evaluation tool box to identify the factors that lead to impact and how the impact was achieved. A similar approach to focus on the barriers to KT impact would enrich these findings and could be a useful priority for future research.

In short, this research provided a robust evaluation that demonstrated a positive impact of KT participation on farm level performance driven by the provision of relevant content delivered by a skilled adviser through various activity formats and ultimately relies on the motivation of the farmer to learn and implement new practices. From a practical and policy perspective, this analysis outlines areas for future focus.

**Recommendations: Practice and Policy**

This research has several policy and practical implications. Providing a KT service that focuses on the aspects that benefit farmers most is a useful blueprint to implement strategies focused on profitability gain. These recommendations are outlined below:

Firstly, this analysis shows a benefit to participating in KT that should incentivise increased numbers of farmers to enrol. Although it has been acknowledged that financial impact is only one of several types of impact participants can gain from KT services, the impact on financial performance should be communicated effectively. This benefit is both for profitability and farm income distinguished on their inclusion or exclusion of subsidies obtained through scheme assistance interactions with advisers.

Second, KT services need to be resourced adequately in order to continue to achieve a positive impact. Client ratios per adviser should be reduced, and new advisers recruited to lower these ratios. However, the importance of trust and the time necessary to build these trust-based relationships incurs a time lag, so medium-term strategies should be introduced to facilitate efficient KT services. In addition, given the public nature of the

KT service in the study, resources should be allocated to ensure spatial asymmetries are reduced by ensuring ubiquitous access where feasible.

Third, the role of the farmer within KT requires further emphasis in the design of KT strategies to increase the likelihood of implementing newly acquired knowledge. This research aimed to address this issue and the farmers interviewed commented that many farmers do not implement the new techniques they had learned. The visualisation of a practice and the peer pressure effect were identified as significant push factors along with the influence of the adviser. The inclusion of farmers in the design process (Kilpatrick and Johns 2003) is one possibility in order to make the service more responsive to the demands of farmers, as opposed to prioritising knowledge that is not necessarily desired. This refers both to the content of KT exchanges as well as the activities employed with a preference for discussion group models although an acknowledgement that one-to-one consultations are necessary for individual scenarios reliant on specific advice.

Fourth, KT services can be used more effectively as a policy instrument to achieve sector objectives as set by policymakers such as Food Wise 2025 in Ireland. Increased productivity, profitability and sustainability are among the key objectives of this strategy and this analysis outlines a pathway to deliver impactful KT to assist the achievement of these objectives through specific interactions that are implemented at farm level. Although this analysis focused on profitability and productivity, the interactions can be transferred to alternative functions such as environmental protection, innovations and rural development.

**Caveats and Future Work**

The contributions of this research extend the existing literature, but there are some limitations and areas that can develop further. These caveats and further research are outlined below.

Firstly, although this research quantifies the impact for KT participation in an econometrically appropriate method, the variable of focus was limited to a dummy variable with a value of 1 for KT participation and 0 otherwise. However, there are various levels of KT participation all at varying levels of intensity. For example the basic KT package includes scheme assistance duties, newsletters and invitations to farm events. Deeper levels of participation include discussion group membership and on-farm visits. These differing levels of participation would yield additional insight and precision to the

specific KT interactions that are most profitable to farmers. In order to achieve this, it is necessary to develop variables that distinguish between the levels of participation. The advisory fee variable was tested but given the overlap in services it was unclear what service the fee related to. Additional data collected as per the Teagasc NFS would be useful to distinguish between the types of KT activities farmers participate in, the intensity of that contact and if possible a measure of the farmers primary motivation to participate in terms of a desired outcome. More recently the Teagasc NFS has included a variable on participation in discussion groups for each enterprise, and to accommodate these in future analysis will yield additional insights. This is a key area that could be developed for future research.

Secondly, the measure of impact adopted for this study was based on financial performance from production on the basis of providing a common measure across all farm enterprise types. However, there are several other examples of impact that are worthy of further research. Specifically from the Birner et al. (2009) framework rural employment, distributional effects, environmental effects, empowerment, gender specific impact and value chain effects are alternative options. Labour and social isolation were also identified in the qualitative analysis as areas for further research. These measures require alternative variables to measure accurately, variables that were not available for this study.

The qualitative study utilised a purposive sample in order to prioritise informants who were deemed as most relevant to the research questions (Creswell 2009). This sample was selected on the basis that the informants were more likely to be involved in KT services that yielded the highest level of impact, namely through progressive dairy farms in advantageous regions. However, a significant proportion of the Irish farming population would not relate to these farmers, particularly so for extensive cattle and sheep systems. These systems are more likely to rely on subsidy assistance to retain viability and are less likely to engage with KT for technical based advice on production. A comparative analysis to examine the impact of KT on farmers motivated solely by subsidy drawdown would be interesting to distinguish the level of impact for farmers with alternative motivations to participate. The inclusion of these farmers and their insights would add further value to this research. Furthermore, the advisers interviewed did not experience a significant increase in their client ratios as reported in Chapter 5. By including advisers who did experience a significant increase, the analysis could explain the impact on staff from the organisational consolidation more representatively. The inclusion of these participants would enrich the findings presented here.

Finally, another caveat to this study is although Teagasc represents a unique public organisational structure, there is a substantial, albeit fragmented, private KT component for advice in Ireland (Prager and Thomson 2014) which is not captured in this analysis. Most private organisations are micro with typically less than 3 full time advisers, and thus it is difficult to obtain useful data for comparison. However, it has to be acknowledged that these are an important aspect of KT that impact farm level performance and to accommodate their influence on KT impact would extend this analysis further. A cost-benefit analysis on the provision of KT related to the subsequent impact would also enrich the quantitative analysis. This would require an estimation of the costs associated with providing the service for the KT organisation, and evaluating the ratio of benefit accrued at farm level. The cost is likely to remain relatively stable year on year whereas the profitability at farm level would vary and to accommodate this annual variation would be interesting.

## Conclusion

This study provided a robust analysis on the impact of KT services on farm level by quantitatively estimating the impact and qualitatively exploring the process that drove this impact. The multi-methods approach utilised in this analysis ensured a robust and valid analysis which addressed the dual research questions of *what* the level of KT impact was and also *how* this impact was achieved. This approach provides a useful addition to evaluation based analyses techniques in order to deepen our understanding of how agricultural KT can achieve a positive impact on farm level outcomes. The findings showed a positive impact for participating farmers, although this impact was confounded by the need to efficiently deploy resources to ensure symmetrical access for public KT organisations. Also the role of both farmers and advisers within the KT process can drive or hinder impact but each phase along the process must be underpinned by trust to facilitate learning and implementation of new knowledge at farm level.

This study provides a valuable contribution to existing literature on the evaluation of KT related impact, but could be advanced further in a number of ways. Firstly, by distinguishing between the levels of KT participation in the quantitative analysis would yield more evidence on the activity that is most impactful at increasing farm level performance. This would build on the divergence identified in the qualitative analysis with advisers favouring the one-to-one consultation and farmers preferring the discussion groups. Similarly, to distinguish between the intensity of participation would also enrich

the analysis to determine any cumulative benefits for higher levels of interactions. Secondly, to apply the methods used in this analysis to other forms of impact would also develop on the findings presented here. For example, environmental challenges will continue to influence policy formulation in the future and the need to influence farm behaviour through KT interactions will be key. Finally, although this study prioritised the positive impact of KT on farm level impact, the reverse could also provide important learnings for policy makers and KT organisations. To identify formats of KT that do not achieve an impact would provide additional insights into the factors that act as barriers to KT participation and impact. These examples would build on the evidence provided in this study to deepen our understanding of the drivers of KT related impact at farm level.

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# Appendices

## Appendix A – Teagasc Overview[3]

Teagasc is the public agricultural Knowledge Transfer (KT) provider in Ireland. 'Teagasc' which is a Gaelic word for 'teaching' was established in 1988 to amalgamate agricultural research, education and extension under a single organisational structure, which is an autonomous state agency. This integrated organisational structure ensures an efficient communication channel between research specialists and advisers to transfer knowledge to participating farmers. The content is delivered to farmers through a series of activities including discussion groups, one-to-one consultations, open day exhibitions, farm walks and through a series of publications. Discussion groups refer to groups of approximately 15 farmers that meet monthly on each other's farm to discuss a particular topic facilitated by the adviser. One-to-one consultations are individual interactions between the adviser and farmer. Open day exhibitions are mass events on a specific enterprise that present emerging research and knowledge priorities. Farm walks can be hosted by a specific farmer or on a Teagasc owned research demonstration farm where a particular enterprise is trialled. These farms include the Teagasc BETTER farms which are the 'Business, Environmental and Technology through Extension and Research' farms where participating farmers receive intensive advice to improve farm efficiency. Finally the publications include T research which is a quarterly update on research, Today's farm which is a bimonthly magazine and monthly newsletters.

Participating farmers can participate at a range of different intensities which are reflected in the level of fee paid. For example, a basic KT contract includes phone contact, scheme assistance, invitations to events, newsletters and basis advice and the cost ranges from €155 to €295 depending on the size of the farm in question (prices at 2018 levels). Farmers then can add discussion group membership, one-to-one on farm consultations, derogations and specific issues for an additional cost.

[3] (source www.teagasc.ie)

The specific services offered to participating farmers include:

- An adviser with full access to specialist and research backup
- On-farm visits, according to contract
- Herd and flock management advice
- Business and financial planning
- Office and phone consultations
- Farm management advice
- Grassland management planning service
- Breeding advice
- Nutrition and ration formulation service
- Advice on farm buildings and paddock layout
- Assistance with Department of Agriculture schemes
- Options planning for the future
- Advice on alternative enterprise development
- Joint programmes with industry
- Participation in enterprise-based discussion groups
- Farm partnership services
- The Teagasc E-Profit monitor
- Environmental and planning advice
- Soil and grass analysis service
- Access to farm walks, demonstrations and public events
- A monthly newsletter with practical and timely advice

- Today's farm magazine bi-monthly
- BETTER farm programmes
- Access to adult farmer education courses and programmes
- An independent and confidential advisory service

The three services of most relevance to this study are underlined in the list, namely technical advice related to grassland and breeding management, and financial advice related to the E-profit monitor.

## Appendix B – Full Table of OLS and IV Estimates

| | Coeff | SE | p | Coeff | SE | p |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | **OLS Regression** | | | **Instrumental Variable Regression – 1 Instrument** | | |
| Has Advisory Participation | 0.19 | 0.02 | 0.00 | 0.35 | 0.41 | 0.00 |
| Log Land Value per Ha | 0.15 | 0.02 | 0.00 | 0.15 | 0.02 | 0.00 |
| Dairy System | 0.34 | 0.03 | 0.00 | 0.37 | 0.03 | 0.00 |
| Dairy and Other System | -0.09 | 0.04 | 0.03 | -0.06 | 0.04 | 0.16 |
| Cattle Rearing | -0.19 | 0.03 | 0.00 | -0.15 | 0.03 | 0.00 |
| Cattle Other System | -0.19 | 0.03 | 0.00 | -0.16 | 0.03 | 0.00 |
| Mainly Sheep | -0.08 | 0.03 | 0.02 | -0.03 | 0.03 | 0.39 |
| Tillage | 0.26 | 0.05 | 0.00 | 0.29 | 0.05 | 0.00 |
| Log of Family Labour (unpaid) | -0.15 | 0.02 | 0.00 | -0.14 | 0.02 | 0.00 |
| Age | 0.01 | 0.01 | 0.13 | 0.01 | 0.01 | 0.08 |
| Age Squared | -0.00 | 0.00 | 0.11 | -0.00 | 0.00 | 0.06 |
| Has off farm employment | -0.12 | 0.02 | 0.00 | -0.13 | 0.02 | 0.00 |
| Log Farm Size | 0.02 | 0.02 | 0.22 | 0.00 | 0.02 | 0.87 |
| Has Forestry | -0.05 | 0.04 | 0.22 | -0.09 | 0.04 | 0.05 |
| Completed Agricultural Short Course | 0.22 | 0.03 | 0.00 | 0.21 | 0.03 | 0.00 |
| Completed Agricultural Certificate | 0.20 | 0.03 | 0.00 | 0.18 | 0.03 | 0.00 |
| Completed Agricultural University | 0.25 | 0.06 | 0.00 | 0.24 | 0.06 | 0.00 |
| Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth | omitted | omitted | omitted | omitted | omitted | omitted |
| Dublin | -0.13 | 0.03 | 0.00 | -0.13 | 0.03 | 0.00 |
| Kildare, Meath, Wicklow | -0.21 | 0.08 | 0.01 | -0.21 | 0.08 | 0.01 |
| Laois, Longford, Offaly, Westmeath | -0.18 | 0.04 | 0.00 | -0.18 | 0.04 | 0.00 |
| Clare, Limerick, Tipp. N.R. | -0.17 | 0.04 | 0.00 | -0.14 | 0.04 | 0.00 |
| Carlow, Kilkenny, Wexford, Tipp S.R., Waterford | 0.01 | 0.04 | 0.88 | 0.02 | 0.04 | 0.66 |
| Cork, Kerry | -0.15 | 0.04 | 0.00 | -0.17 | 0.04 | 0.00 |
| Galway, Mayo, Roscommon | 0.00 | 0.03 | 0.98 | 0.00 | 0.03 | 0.95 |
| Stocking Density | 0.42 | 0.02 | 0.00 | 0.40 | 0.02 | 0.00 |
| Medium Soil | -0.07 | 0.02 | 0.00 | -0.08 | 0.02 | 0.00 |
| Poor Soil | -0.01 | 0.04 | 0.77 | -0.03 | 0.03 | 0.37 |
| Constant | 5.08 | 0.17 | 0.00 | 5.05 | 0.17 | 0.00 |
| | | | | | | |
| Number of Observations | 8,951 | | | 8,951 | | |
| Centred R2 | 0.22 | | | 0.22 | | |
| Cragg-Donald Wald F Statistic (Weak Instrument) | | | | 2639.20 | | |
| Sargan statistic p value (Overidentification Test) | | | | 0.000 | | |

*Note: endogenous regressor (Advisory Participation); 1 instrument (Single Farm Payment year policy change); Border region omitted for collinearity; dairy system omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity; p value > 0.1 denotes significance at the 10% level, p value > 0.05 at 5% and p value > 0.01 at 1%; Stock, Wright, and Yogo (2002) argue Wald F Statistic <10 considered weak; Sargan Statistic void due to equation exactly identified*

| | Coeff | SE | p | Coeff | SE | p |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | **Instrumental Variable Regression – 2 Instruments** | | | **Instrumental Variable Regression – 3 Instruments** | | |
| Has Advisory Participation | 0.35 | 0.04 | 0.00 | 0.35 | 0.04 | 0.00 |
| Log Land Value per Ha | 0.15 | 0.02 | 0.00 | 0.15 | 0.02 | 0.00 |
| Dairy System | 0.37 | 0.03 | 0.00 | 0.37 | 0.03 | 0.00 |
| Dairy and Other System | -0.06 | 0.04 | 0.16 | -0.06 | 0.04 | 0.16 |
| Cattle Rearing | -0.15 | 0.03 | 0.00 | -0.15 | 0.03 | 0.00 |
| Cattle Other System | -0.16 | 0.03 | 0.00 | -0.16 | 0.03 | 0.00 |
| Mainly Sheep | -0.03 | 0.03 | 0.38 | -0.03 | 0.03 | 0.37 |
| Tillage | 0.29 | 0.05 | 0.00 | 0.29 | 0.05 | 0.00 |
| Log of Family Labour (unpaid) | -0.14 | 0.02 | 0.00 | -0.14 | 0.02 | 0.00 |
| Age | 0.01 | 0.01 | 0.08 | 0.01 | 0.01 | 0.08 |
| Age Squared | -0.00 | 0.00 | 0.06 | -0.00 | 0.00 | 0.06 |
| Has off farm employment | -0.13 | 0.02 | 0.00 | -0.13 | 0.02 | 0.00 |
| Log Farm Size | 0.00 | 0.02 | 0.87 | 0.00 | 0.02 | 0.85 |
| Has Forestry | -0.09 | 0.04 | 0.05 | -0.09 | 0.04 | 0.05 |
| Completed Agricultural Short Course | 0.21 | 0.03 | 0.00 | 0.21 | 0.03 | 0.00 |
| Completed Agricultural Certificate | 0.18 | 0.03 | 0.00 | 0.18 | 0.03 | 0.00 |
| Completed Agricultural University | 0.24 | 0.06 | 0.00 | 0.24 | 0.06 | 0.00 |
| Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth | omitted | omitted | omitted | omitted | omitted | omitted |
| Dublin | -0.13 | 0.03 | 0.00 | -0.13 | 0.03 | 0.00 |
| Kildare, Meath, Wicklow | -0.21 | 0.08 | 0.01 | -0.21 | 0.08 | 0.01 |
| Laois, Longford, Offaly, Westmeath | -0.18 | 0.04 | 0.00 | -0.18 | 0.04 | 0.00 |
| Clare, Limerick, Tipp. N.R. | -0.15 | 0.04 | 0.00 | -0.15 | 0.04 | 0.00 |
| Carlow, Kilkenny, Wexford, Tipp S.R., Waterford | 0.016 | 0.04 | 0.66 | 0.02 | 0.04 | 0.66 |
| Cork, Kerry | -0.17 | 0.04 | 0.00 | -0.17 | 0.04 | 0.00 |
| Galway, Mayo, Roscommon | 0.00 | 0.03 | 0.95 | 0.00 | 0.03 | 0.95 |
| Stocking Density | 0.40 | 0.02 | 0.00 | 0.41 | 0.02 | 0.00 |
| Medium Soil | -0.08 | 0.02 | 0.00 | -0.08 | 0.02 | 0.00 |
| Poor Soil | -0.03 | 0.03 | 0.37 | -0.03 | 0.03 | 0.38 |
| Constant | 5.05 | 0.17 | 0.00 | 5.05 | 0.17 | 0.00 |
| | | | | | | |
| Number of Observations | 8,951 | | | 8,951 | | |
| Centred R2 | 0.22 | | | 0.22 | | |
| Cragg-Donald Wald F Statistic (Weak Instrument) | 1331.86 | | | 891.43 | | |
| Sargan statistic p value (Overidentification Test) | 0.81 | | | | | |

*Note: endogenous regressor (Advisory Participation in both models); 2 instruments (Single Farm Payment policy change and Distance to advisory office); 3 Instruments (Single Farm Payment policy change, Distance to advisory office and Interaction of both); Border region omitted for collinearity; dairy system omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity; p value > 0.1 denotes significance at the 10% level, p value > 0.05 at 5% and p value > 0.01 at 1%; Stock, Wright, and Yogo (2002) argue Wald F Statistic <10 considered weak; Sargan Statistic for overidentification p value > 0.1 fails to reject null hypothesis of instruments validity*

## Appendix C – Full Table of IV estimates with 1 Instrument only (2000-2013)

| | Coeff | SE | p | Coeff | SE | p |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | **Instrumental Variable Regression – Sfpyr only** | | | **Instrumental Variable Regression –1 Dist. only** | | |
| Has Advisory Participation | 0.35 | 0.41 | 0.00 | 0.14 | 0.57 | 0.79 |
| Log Land Value per Ha | 0.15 | 0.02 | 0.00 | 0.15 | 0.03 | 0.00 |
| Dairy System | 0.37 | 0.03 | 0.00 | 0.34 | 0.09 | 0.00 |
| Dairy and Other System | -0.06 | 0.04 | 0.16 | -0.09 | 0.12 | 0.42 |
| Cattle Rearing | -0.15 | 0.03 | 0.00 | -0.19 | 0.15 | 0.19 |
| Cattle Other System | -0.16 | 0.03 | 0.00 | -0.20 | 0.14 | 0.13 |
| Mainly Sheep | -0.03 | 0.03 | 0.39 | -0.09 | 0.17 | 0.59 |
| Tillage | 0.29 | 0.05 | 0.00 | 0.25 | 0.09 | 0.01 |
| Log of Family Labour (unpaid) | -0.14 | 0.02 | 0.00 | -0.14 | 0.02 | 0.00 |
| Age | 0.01 | 0.01 | 0.08 | 0.01 | 0.01 | 0.09 |
| Age Squared | -0.00 | 0.00 | 0.06 | -0.00 | 0.00 | 0.12 |
| Has off farm employment | -0.13 | 0.02 | 0.00 | -0.12 | 0.03 | 0.00 |
| Log Farm Size | 0.00 | 0.02 | 0.87 | 0.03 | 0.07 | 0.71 |
| Has Forestry | -0.09 | 0.04 | 0.05 | -0.05 | 0.12 | 0.71 |
| Completed Agricultural Short Course | 0.21 | 0.03 | 0.00 | 0.23 | 0.06 | 0.00 |
| Completed Agricultural Certificate | 0.18 | 0.03 | 0.00 | 0.21 | 0.07 | 0.01 |
| Completed Agricultural University | 0.24 | 0.06 | 0.00 | 0.26 | 0.07 | 0.00 |
| Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth | omitted | omitted | omitted | omitted | omitted | omitted |
| Dublin | -0.13 | 0.03 | 0.00 | -0.13 | 0.03 | 0.00 |
| Kildare, Meath, Wicklow | -0.21 | 0.08 | 0.01 | -0.21 | 0.08 | 0.01 |
| Laois, Longford, Offaly, Westmeath | -0.18 | 0.04 | 0.00 | -0.18 | 0.05 | 0.00 |
| Clare, Limerick, Tipp. N.R. | -0.14 | 0.04 | 0.00 | -0.17 | 0.09 | 0.05 |
| Carlow, Kilkenny, Wexford, Tipp S.R., Waterford | 0.02 | 0.04 | 0.66 | 0.00 | 0.05 | 0.98 |
| Cork, Kerry | -0.17 | 0.04 | 0.00 | -0.15 | 0.07 | 0.04 |
| Galway, Mayo, Roscommon | 0.00 | 0.03 | 0.95 | -0.00 | 0.03 | 0.98 |
| Stocking Density | 0.40 | 0.02 | 0.00 | 0.42 | 0.05 | 0.00 |
| Medium Soil | -0.08 | 0.02 | 0.00 | -0.08 | 0.02 | 0.00 |
| Poor Soil | -0.03 | 0.03 | 0.37 | -0.00 | 0.08 | 0.96 |
| Constant | 5.05 | 0.17 | 0.00 | 4.97 | 0.21 | 0.00 |
| | | | | | | |
| Number of Observations | 8,951 | | | | 8,951 | |
| Centred R2 | 0.22 | | | | 0.22 | |
| Cragg-Donald Wald F Statistic (Weak Instrument) | 2639.20 | | | | 10.78 | |
| Sargan statistic p value (Overidentification Test) | 0.000 | | | | 0.000 | |

*Note: endogenous regressor (Advisory Participation in both models); 1instrument in each (Single Farm Payment policy change and Distance to advisory office respectively); Border region omitted for collinearity; dairy system omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity; p value > 0.1 denotes significance at the 10% level, p value > 0.05 at 5% and p value > 0.01 at 1%; Stock, Wright, and Yogo (2002) argue Wald F Statistic <10 considered weak*

## Appendix D – OLS Estimates (2000-2004; 2005-2013)

| | Coeff | SE | p | Coeff | SE | p |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | **OLS Model pre 2005** | | | **OLS Model post 2005** | | |
| Has Advisory Participation | 0.09 | 0.02 | 0.00 | 0.15 | 0.02 | 0.00 |
| Log Land Value per Ha | 0.19 | 0.03 | 0.00 | 0.15 | 0.02 | 0.00 |
| Dairy System | 0.16 | 0.07 | 0.02 | 0.31 | 0.03 | 0.00 |
| Dairy and Other System | -0.29 | 0.07 | 0.00 | -0.04 | 0.04 | 0.37 |
| Cattle Rearing | -0.38 | 0.06 | 0.00 | -0.17 | 0.03 | 0.00 |
| Cattle Other System | -0.56 | 0.06 | 0.00 | -0.14 | 0.03 | 0.00 |
| Mainly Sheep | -0.39 | 0.06 | 0.00 | -0.09 | 0.03 | 0.01 |
| Tillage | omitted | omitted | omitted | 0.28 | 0.05 | 0.00 |
| Log of Family Labour (unpaid) | -0.08 | 0.03 | 0.01 | -0.12 | 0.02 | 0.00 |
| Age | -0.00 | 0.01 | 0.86 | 0.01 | 0.01 | 0.181 |
| Age Squared | 0.00 | 0.00 | 0.95 | -0.00 | 0.00 | 0.16 |
| Has off farm employment | -0.13 | 0.03 | 0.00 | -0.11 | 0.02 | 0.00 |
| Log Farm Size | 0.01 | 0.02 | 0.81 | 0.04 | 0.02 | 0.01 |
| Has Forestry | omitted | omitted | omitted | -0.03 | 0.04 | 0.38 |
| Completed Agricultural Short Course | 0.27 | 0.04 | 0.00 | 0.16 | 0.03 | 0.00 |
| Completed Agricultural Certificate | 0.13 | 0.03 | 0.00 | 0.21 | 0.03 | 0.00 |
| Completed Agricultural University | -0.04 | 0.09 | 0.65 | 0.28 | 0.06 | 0.00 |
| Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth | omitted | omitted | omitted | omitted | omitted | omitted |
| Dublin | -0.18 | 0.04 | 0.00 | -0.15 | 0.03 | 0.00 |
| Kildare, Meath, Wicklow | -0.01 | 0.11 | 0.94 | -0.31 | 0.09 | 0.00 |
| Laois, Longford, Offaly, Westmeath | -0.17 | 0.05 | 0.00 | -0.18 | 0.04 | 0.00 |
| Clare, Limerick, Tipp. N.R. | -0.21 | 0.05 | 0.00 | -0.19 | 0.04 | 0.00 |
| Carlow, Kilkenny, Wexford, Tipp S.R., Waterford | -0.03 | 0.04 | 0.48 | -0.04 | 0.04 | 0.30 |
| Cork, Kerry | -0.37 | 0.05 | 0.00 | -0.05 | 0.04 | 0.12 |
| Galway, Mayo, Roscommon | -0.15 | 0.04 | 0.00 | -0.01 | 0.03 | 0.76 |
| Stocking Density | 0.46 | 0.02 | 0.00 | 0.41 | 0.02 | 0.00 |
| Medium Soil | -0.17 | 0.03 | 0.00 | -0.08 | 0.02 | 0.00 |
| Poor Soil | 0.03 | 0.04 | 0.47 | 0.01 | 0.03 | 0.77 |
| Constant | 5.69 | 0.21 | 0.00 | 5.07 | 0.17 | 0.00 |
| | | | | | | |
| Number of Observations | 4,503 | | | 8,875 | | |
| $R^2$ | 0.30 | | | 0.19 | | |
| F stat | 76.61 | | | 75.19 | | |

*Note: Border region omitted for collinearity; dairy system omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity; p value > 0.1 denotes significance at the 10% level, p value > 0.05 at 5% and p value > 0.01 at 1%*

## Appendix E – Condensed Model (2000-2013)

| | Coeff | SE | Z | p | CI | CI |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | | | | | | |
| Has Advisory Participation | 0.31 | 0.04 | 7.95 | 0.00 | 0.23 | 0.38 |
| Log Land Value per Ha | 0.26 | 0.02 | 13.47 | 0.00 | 0.22 | 0.38 |
| Age | 0.03 | 0.01 | 4.74 | 0.00 | 0.02 | 0.04 |
| Age Squared | -0.00 | 0.00 | -5.07 | 0.00 | -0.00 | -0.00 |
| Completed Agricultural Short Course | 0.26 | 0.03 | 8.58 | 0.00 | 0.20 | 0.32 |
| Completed Agricultural Certificate | 0.33 | 0.03 | 12.55 | 0.00 | 0.28 | 0.39 |
| Completed Agricultural University | 0.39 | 0.06 | 6.21 | 0.00 | 0.27 | 0.52 |
| Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth | omitted | omitted | omitted | omitted | omitted | omitted |
| Dublin | -0.14 | 0.03 | -4.65 | 0.00 | -0.20 | -0.08 |
| Kildare, Meath, Wicklow | -0.28 | 0.08 | -3.35 | 0.00 | -0.44 | -0.12 |
| Laois, Longford, Offaly, Westmeath | -0.11 | 0.04 | -2.61 | 0.01 | -0.18 | -0.03 |
| Clare, Limerick, Tipp. N.R. | -0.22 | 0.04 | -5.50 | 0.00 | -0.29 | -0.14 |
| Carlow, Kilkenny, Wexford, Tipp S.R., Waterford | -0.06 | 0.04 | -1.67 | 0.10 | -0.13 | 0.01 |
| Cork, Kerry | -0.15 | 0.04 | -3.99 | 0.00 | -0.21 | -0.07 |
| Galway, Mayo, Roscommon | 0.12 | 0.03 | 3.89 | 0.00 | 0.06 | 0.19 |
| Medium Soil | -0.17 | 0.02 | -8.15 | 0.00 | -0.22 | -0.13 |
| Poor Soil | -0.16 | 0.03 | -4.82 | 0.00 | -0.22 | -0.09 |
| Constant | 5.11 | 0.17 | 30.64 | 0.00 | 4.79 | 5.44 |
| | | | | | | |
| Number of Observations | 8,951 | | | | | |
| Centred R2 | 0.12 | | | | | |
| Cragg-Donald Wald F Statistic (WeakInstrument) | 1118.8 | | | | | |
| Sargan statistic p value (Overidentification Test) | 0.19 | | | | | |

*Note: endogenous regressor (Advisory Participation); 3 Instruments (Single Farm Payment policy change, Distance to advisory office and Interaction of both); Border region omitted for collinearity; good soil omitted for collinearity; standard errors adjusted for heterogeneity; p value > 0.1 denotes significance at the 10% level, p value > 0.05 at 5% and p value > 0.01 at 1%; Stock, Wright, and Yogo (2002) argue Wald F Statistic <10 considered weak*

## Appendix F – Difference in Difference Model (2000-2013)

| | Coeff | SE | t | p | CI | CI |
|---|---|---|---|---|---|---|
| **Dependent Variable = Log of Farm Family Income per ha** | | | | | | |
| Single farm payment year | -0.03 | 0.03 | -1.21 | 0.23 | -0.08 | 0.02 |
| Treated group | -0.28 | 0.03 | -10.76 | 0.00 | -0.33 | -0.23 |
| Interaction term SFP*Treated | 0.28 | 0.03 | 7.85 | 0.00 | 0.21 | 0.34 |
| Constant | 6.10 | 0.02 | 366.6 | 0.00 | 6.06 | 6.13 |
| Number of Observations | 13,562 | | | | | |
| $R^2$ | 0.01 | | | | | |

*Note: advisory participation treated for those who only became clients after the introduction of the Single farm payment policy change in 2005*

## Appendix G – Project Overview provided to interviewees

**Project title: The impact of knowledge transfer participation on farm level profitability**

Walsh Fellowship PhD Research – Teagasc (REDP) and NUI Galway

### Overall project objectives

1. Quantify the economic benefits on farm level of knowledge transfer participation.
2. Provide a more refined measure of impact on farm level profitability during a period of organisational consolidation.
3. Explore the underpinning processes that lead to farm level impact from knowledge transfer particpation.

### Focus

- What is the benefit of knowledge transfer participation on farm level finances?
- What was the impact on farm profits during the organisational consolidation from the economic crisis?
- What is the role of the adviser in achieving farm level impact and how has this role evolved in recent times?
- What is the role of the client in the process of achieving impact and what are the key factors that lead to improved profits from KT participation?

### Project background

The purpose of this project is two-fold: first, to quantify the impact of knowledge transfer participation on farm level profitability and second, to improve our understanding of how this impact is achieved by exploring the processes that drive it. Work is complete on the former, i.e. there is a net benefit to KT participation for clients and this remained the case over the economic crisis but the increased ratio of clients

per adviser was particularly challenging. The identification of the key processes that drive this positive impact are on-going through planned interviews with key informants on both the adviser and participating farmer side. The aim of the interviews are next outlined.

**Interviews**

The overall objective of the interviews is to identify the key drivers of and barriers to impact through the knowledge transfer process. The interviews should help identify what type of activity and content make an impact, or not, on farm level profitability. To this end the following information should be garnered:

- The role of the adviser in achieving farm level impact – investigation into the types of (un)successful activities/content that are important
- Farmers' expected financial gains from KT participation – i.e. their motivation to participate in KT
- The KT activities/content farmers consider most important to improve their farms financial performance
- Factors facilitating or impeding KT impact on farm profit – drivers and barriers e.g. can knowledge transfer be improved and if so how?

| **Questions for advisers** |
|---|
| Role and influence in making a practical improvement on farm profit (examples) |
| How impact is achieved (important parts of the process/content) |
| Type of KT activity that leads to impact (individual/group/mass based interaction) |
| Benefits and criticisms of these types |
| Example of a grassland programme that improved profits |
| Benefits and criticisms of the E-profit monitor system |
| The evolution of Teagasc KT in recent times. Better or worse now? |
| How they managed the changed workload and increased no. of clients |

| **Questions for farmers** |
|---|
| Aspects of KT that lead to improved farm profitability. Examples |
| How the adviser facilitated the activity that improved your farm |
| Type of KT activity that leads to impact (individual/group/mass based interaction) |
| Benefits and criticisms of these types |
| Example of a grassland programme that improved profits |

| |
|---|
| Benefits and criticisms of the E-profit monitor system |
| The evolution of Teagasc KT in recent times. Better or worse now? |

The findings should help to improve knowledge transfer to farmers and ultimately increase the efficiency of service delivery by focusing on the main factors that lead to impact.

**Appendix H – Letter of Consent signed by interviewees**

# Letter of Consent

I the undersigned, declare that I am willing to take part in this research which is conducted by Anthony Cawley in conjunction with Teagasc as part of a research project.

Title of Study: **The impact of knowledge transfer participation on farm level profitability**

Project Background: The purpose of this project is to identify factors within the knowledge transfer process that lead to impact on farm level profitability. The objective of the interview is to identify the drivers of and barriers to impact with regard to financial performance and to gain an understanding of how the service has evolved in recent times

□ I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.

□ The nature of my participation has been explained to me and I have full knowledge of how the information collected will be used.

□ I fully understand that there is no obligation on me to participate in this study and that I am free to withdraw my participation at any time without having to explain or give a reason.

□ I am also entitled to full confidentiality in terms of my participation and personal details.

Signature: _____ Date:_____

## Appendix I – Qualitative Interview Schedule

Given the information required to further explain the quantitative papers with qualitative insight, an interview schedule was drawn up to deliver to advisers and farmers. It is important to note that particular questions may not yield the expected evidence (Prager et al. 2017). Accordingly the questions were open-ended designed to stimulate conversational answers so the key themes could be extracted from the responses. A list of suggested questions is listed below.

*Questions (Adviser):*

1) What is your role in KT, and can you provide an example of how your influence makes a practical improvement on profitability at farm level?

2) How is impact achieved? What are the key processes that drive it? [individual consultation, how farmer learns, implementation on farm, observation etc.] Tell me about the process of KT from initial motivation to participate right through to improved profitability. How knowledge is transferred and applied that ultimately leads to an increase in margin

3) What type of KT activities/content makes the most impact on farm profits? [Individual/group/mass media excl. subsidies]

4) What positive impacts are associated with the discussion group model of KT? [peer-to-peer learning] What is your role within this? What are the main criticisms of this model? [can be applied to other types of KT also i.e. 1-to-1]

5) Can you provide an example of a grassland management programme introduced by KT that farmers would have implemented, thus improving their productivity? What was easy/difficult for farmers? Why?

6) How effective is the E-profit monitor tool for improving farm profitability? What are the barriers to its use by farmers?

7) How has your role changed over the past 10 years? What was the impact of the consolidation on your workload and role? How did you manage an increased number of clients? Why would this have negatively affected farm level impact?

8) How have you managed the increased number of clients since the recruitment moratorium? Give an example of how the reduction of staff affected your ability to achieve impact. In your opinion, what would be an optimum ratio of clients per adviser in your view? In your opinion why do farmers continue to choose Teagasc KT as opposed to private? Why would they renew their contract?

9) What is the main difference as an adviser today compared to before the recession? How has this affected your ability to deliver measurable impact on farm profitability? What has been the impact on the office?

10) In terms of impact on farm level profits, is KT better now than before? Why (not)? In your opinion how well did Teagasc adapt to deliver a service demanded by farmers? With hindsight, do you think they could have done any more to manage the consolidation? Provide examples.

11) What other factors are important in achieving impact on farm level profits? [system, region etc.] Why?

*Questions (Farmer)*

1) What aspect of KT makes a practical improvement to yo*ur farm's profitability? Give a* recent example of a change you implemented that was successful? What part of KT prompted you to make that change? Why?

2) What was the role of the adviser in prompting that change on your farm?

3) In your opinion, what type of KT makes the most impact on farms? [Individual/group/mass media] Why? Is there any specific content you find best? [technology/specific advice]

4) What are the pros and cons of discussion group KT in relation to impact? What are the incentives/barriers to participation? What about one-to-one?

5) Can you provide an example of a grassland management change you have implemented that has improved your profitability? What was easy/difficult about it? Why?

6) Do you use the E-profit monitor? Why (not)? Do you plan to use in the future – why/why not? In your opinion, will this tool improve farm profits?

7) What is different about KT impact with Teagasc now compared to before the recession? Has your participation changed in any way over the years? Provide examples

8) Have changes within Teagasc – specifically reduced staffing – influenced your farm's profitability? How & why (ask for specific examples).

9) Is todays Teagasc more likely to affect profitability than previous methods? Why (not)? What is your motivation to choose Teagasc as opposed to alternative options??

10) How important is the individual adviser to your participation? Does it matter if you were assigned a new adviser tomorrow as long as he was a Teagasc employee?

11) Are there any other factors that affect KT impact on farm? [system, region etc.] Why?