The Impact of Agricultural Knowledge Transfer Resources on Farm Level Profitability during the Economic Recession – A Quantitative Study

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Abstract

Purpose: The outcomes from agricultural knowledge transfer (KT) are dependent on the access to and the quality of services available, coupled with the motivation of prospective clients to implement new skills. Within this context, the allocation of resources particularly in terms of the location of KT offices and number of agricultural advisers are important considerations for understanding KT impact. This quantitative study evaluates the impact of the rationalisation of KT resources on farm profitability for KT clients in Ireland during the recessionary period 2008-2014. *Design/Methodology:* Teagasc, the public KT service provider in Ireland, experienced significant office closures (43%) and staff reduction (38%) during the economic crisis, yet client numbers declined only slightly (4.5%). Administrative data is merged with a panel data set on farm level performance to test the impact of KT through Random Effects estimation. *Findings:* The results show that annual contract holders gained a 12.3% benefit to their market gross margin per hectare over the period. However, there was a negative effect of 0.2% for each additional client assigned to the adviser which averaged at 9.6% per adviser. *Practical Implications:* The quantitative findings provide a measure of impact that represents the value for money for the KT service. The key implication is that the client ratio for advisers should be considered when allocating resources and lower ratios would positively impact client margins. *Theoretical Implications:* This article outlines the value of quantitative studies to estimate impact in a clear translatable manner which can aid the policy discussion around resource deployment particularly in a recessionary period. The employment of a Random Effects estimator on a panel data set provides a solid base for the analysis. *Originality/Value:* This study evaluates the impact of KT on farm level profitability during a recessionary period when resources were constrained, and uses spatial variables and client densities to examine the regional effects.

Key words: knowledge transfer; agricultural advisers; organisational change; panel data

JEL Code: C33, Q10, Q16

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This work was supported by Teagasc under the Walsh Fellowship Programme

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 act as policy levers to influence farmer behaviour and therefore also assist in achieving 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 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 and therefore must be reliably evaluated (Knook et al. 2018). 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 advisory services have increased since the mid-2000s (Faure, Desjeux and Gasselin 2012). Quantitative analyses provide methodological options where results can be generalised to a larger population dependent on the validity 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 of a particular mechanism to achieve its desired objectives (Johnson and Onwuegbuzie 2004). 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 an increased demand on resources. This evaluation is quantitatively assessed by merging administrative data on resources with the Teagasc National Farm Survey (NFS), which is a panel data set that provides information on farm level financial performance. This identifies 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. Cawley et al. 2018; 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 and across farm systems. Specifically, they found that counties located in the south east of the country had lower client adviser ratios per adviser 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 due to 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, Desjeux and Gasselin (2012) for further research. This provides a valuable contribution to future policy discussions on the deployment of resources for public KT providers, by providing evidence on the value that can be attributed to delivering the service.

The remainder of the paper is structured as follows: initially the context for agricultural KT is outlined and the research questions are presented, 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 multitude of objectives. Concomitant with conventional tasks of providing technical assistance to farmers to improve productivity, KT providers must also balance emerging responsibilities on issues such as environmental protection, sustainability and linking small holders to high value and 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 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 horizontal 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 or peer network 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, Llewellyn and Corbeels 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, and therefore 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.

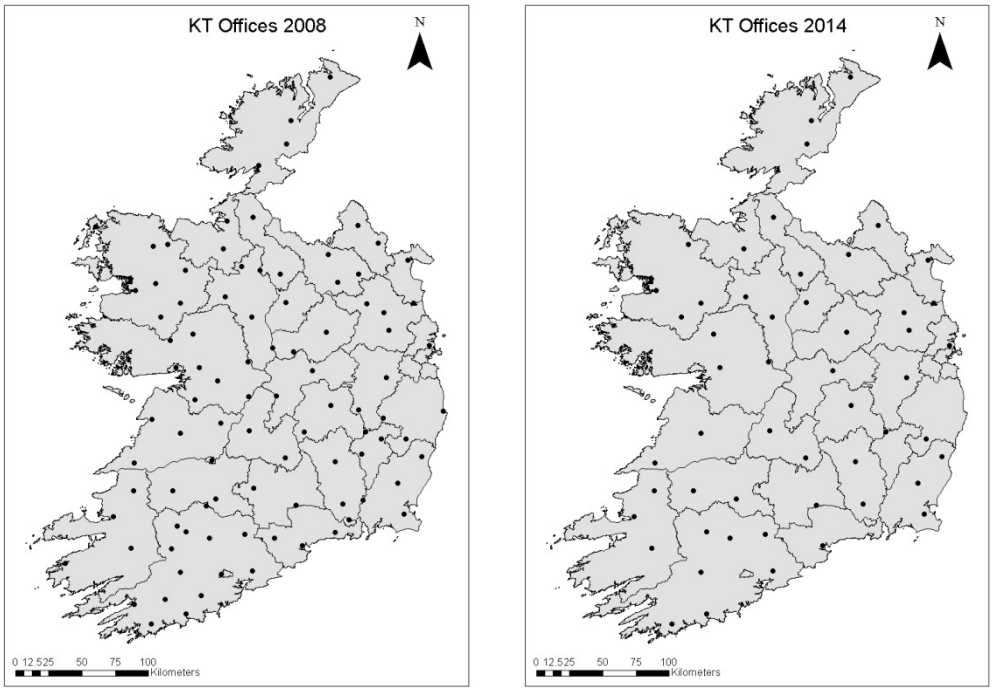
In addition, KT offices may be strategically located in advantaged regions where impact is likely to be more pronounced (Läpple and Hennessy 2015). For example, specific areas may be chosen as more suitable for intensive forms of production based on the soil type which may in turn be selected as ideal locations to base the provision of KT services, given dissemination benefits and the likelihood of participation. Conversely, mountainous areas characterised by more marginal land may not appeal to KT providers given lower profitability levels and expectations of 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, Desjeux and Gasselin 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 during

a consolidation process, and accommodating this issue is a key methodological challenge addressed in this study.

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. However, Teagasc was forced to consolidate resources from 2008 due to fiscal challenges exacerbated by the economic recession. This reaffirmed 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 1. Teagasc client numbers remained relatively static at 41,025 (a slight decrease of 4.5%) over this period.

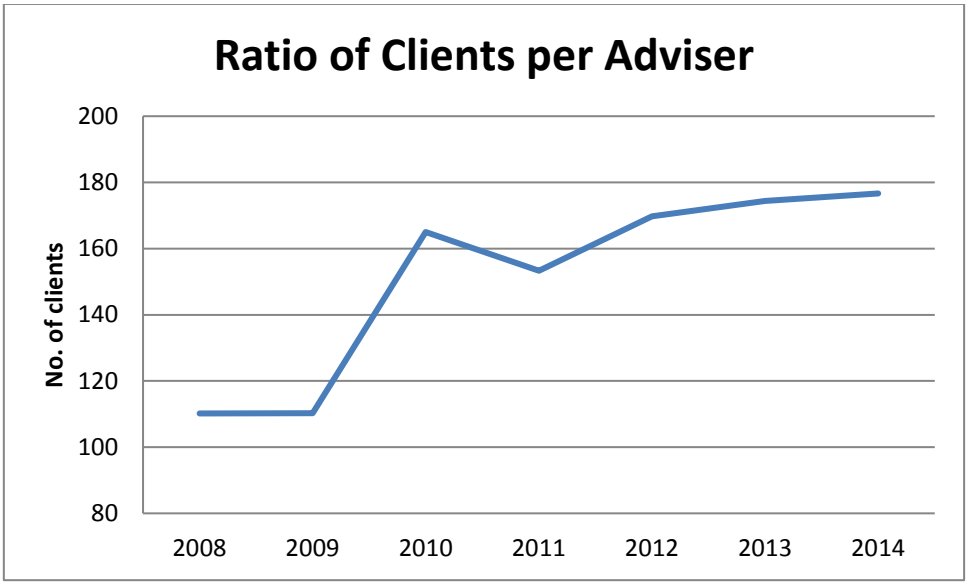
Figure 1 KT Office Closures 2008-2014



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

The ratio of clients per adviser increased significantly over the period, and varied considerably by region. Nationally, the ratio increased by 55.1% on average (see Figure 2). 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 of students and maximise efficiencies. The increased ratio of clients per adviser over this period is presented in Table 1. 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 from office to office but on average the increase was 48 additional clients to each adviser. Regionally the ratio of clients to advisers was lowest in the south west at 124 clients per adviser on average in 2014. Conversely, the highest ratio was recorded in the west over this period with 212 clients per adviser, 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 public 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. It also implies that advisers had less time available to upskill through training programmes which is a vital source of capacity building to deliver KT services (Landini and Brites 2018).

Figure 2 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 1. 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, the regional impact was asymmetrical 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 study.

Research Questions

- What was the impact of the rationalisation of KT resources on farm level profitability?
- How can the use of panel data contribute to policy decisions on the deployment of 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, Hennessy and Newman 2013). 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 with the exception of Läpple et al. (2016), and none that focus 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 multitude 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 level 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 offered 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 study by Onobougo et al. (2014) found that although farmers received more than one visit from extension agents on an annual basis, the impact of these subsequent visits was questionable. Furthermore, the ability of advisers to provide multiple farm visit-based consultations is dependent on their availability which is determined by their ratio of clients and level of responsibility. To address this issue in this study although we also aggregate KT participation into a binary variable, we focus on annual contract holders to imply a more intensive technical advice as opposed to other objectives such as scheme assistance duties. Teagasc annual contracts vary from a basic package that includes some scheme assistance as well as invitations to events and news publications to a more intensive development package that includes discussion group membership and intensive on-farm consultations. 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 based on 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 to ensure a financially comparable outcome measure. Similarly, Coccia (2008) conducted research into the spatial mobility of KT in Italy by focusing 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. This work also 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. The proximity to resources was also linked to a greather use by Krone and Dannenberg (2018). Skevas, Ioannis and Swinton (2018) also found a positive spillover effect for farmers from the actions of their neighbours, and the inclusion of these spatial dependencies gives a more accurate reflection of the true effects of a policy intervention, citing the willingness to rent land for bioenergy crops in their study. 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 studies 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 introduced 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 strain on the deployment of resources. This is achieved by evaluating 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 (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 support 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 the characteristics of existing offices and in terms of their respective number of advisers and clients in each.

Teagasc National Farm Survey (NFS)

The Teagasc 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 due to the economic recession to examine impact since the organisational change was implemented. 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 with a decrease 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, Creaney and Lorenzo-Arribas 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 commonly located 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 annual advisory contracts which exclude scheme assistance and other services. These contracts are assumed to involve more technically based KT to

varying 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 primarily 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 farmer characteristics such as age, education and off-farm employment. Regional dummies were included for eight regions, but the main variables were estimated at a local level. These dummies 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 2.

Table 2. 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

The summary statistics show a diverse spread of farmers with various systems across all regions.

Methodology

There is an inherent difficulty in the 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; Knook et al. 2018), 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). To overcome these challenges, 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 multiple 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 reduces the level of bias associated with each observation.

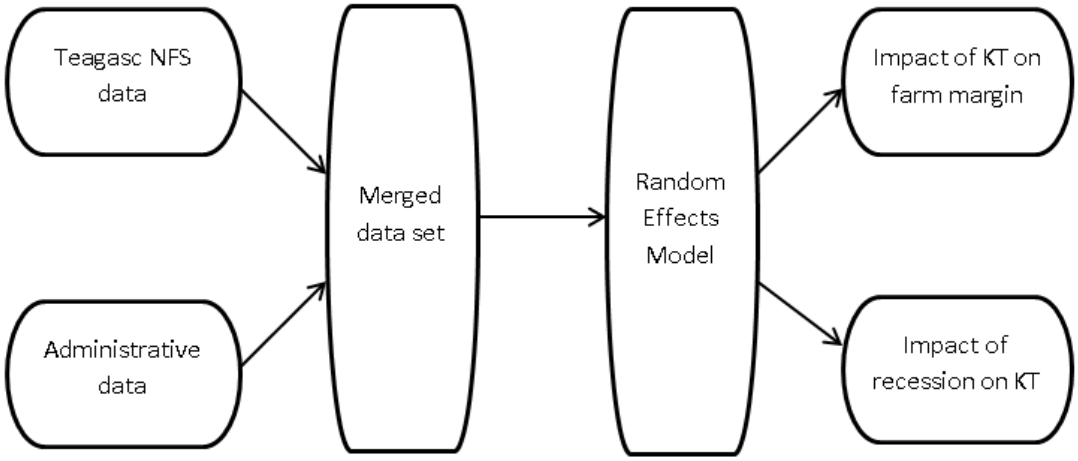
The random effects model is preferred on the basis of two selected criteria. Firstly, random effects models assume that all explanatory variables are uncorrelated with the individual effects (Baltagi and Liu 2012; Gujarati 2003). In other words, the individual effects of each observation are assumed to be random. This enables the individual component associated with heterogeneity of each observation to be absorbed through the error term (Kilcline et al. 2014). Second, although a Hausman test suggested 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 of the estimation as they remain static (Wooldridge 2013). Therefore, 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 Υ_{it} is the dependent variable of market gross margin per hectare for farm i in year t, α_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 ε is the idiosyncratic error term. Furthermore the standard errors are adjusted to control for any heteroscedasticity concerns. Figure 3 summarises the method of analysis for this study.

Figure 3 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 per hectare. The value of this impact was estimated at 12.3% and was statistically significant. Second the increased workload on advisers negatively impacted participants, but this effect was relatively small per additional client at 0.2%. This means that for each additional client assigned to an adviser, the overall margin for clients decreased by 0.2%. While this may seem practically insignificant as advisers typically manage large numbers of clients, when 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 2.9%. Therefore, the regional disparities are evident with a north/south divide emerging. 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 reduces 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 scale of the negative effect of the consolidation somewhat. However, for the purpose of clarity this analysis focused on profitability excluding subsidies. The full set of results is presented in Table 3.

Table 3. 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 of the period 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 over the period.

These findings highlight 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 imposed a cost due to the increased ratios but that the overall benefit of participation is confirmed. This is a key advantage of quantitative studies (Johnson and Onwuegbuzie 2004). It provides 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 on 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 and 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 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 also 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). Furthermore an increased client ratio per adviser implies an opportunity cost in terms of having less time to attend training events which are crucial to continually develop the capacity of the advisers to respond to the needs of a dynamic sector (Landini and Brites 2018). 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

more negatively impacted 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 study 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 study further by explaining the factors that affect KT impact (Knook et al. 2018). 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.

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