The Impact of Extension Services on Farm Level Outcomes: An Instrumental Variable Approach

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Paper prepared for presentation at the 150th EAAE Seminar

"The spatial dimension in analysing the linkages between agriculture, rural development and the environment"

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Abstract

Many studies show that interaction with extension services impact farmer's technology adoption decisions and profitability levels. However, analysis of extension impact across all farm systems whilst controlling for endogeneity biases is less common.

This research attempts to redress that research gap by firstly discussing the various biases related to the motivation to engage with extension services, omitted variable bias and measurement error, and subsequently applying instrumental variable (IV) regression estimation to the relationship between extension engagement and farm level outcomes, namely family farm income over a pooled panel dataset. Distance to the local advisory office and the introduction of a policy change were chosen as valid and relevant instruments.

The results indicate a positive impact of extension engagement on farm income, and imply that an ordinary least squares approach underestimates the benefits of extension engagement. Accordingly, increased advisory activity could improve the performance of the sector significantly, and this could be a useful policy tool to achieve the targets as set out by the Irish governments Food Wise 2025 plan.

Key words: extension services; farm performance; endogeneity; instrumental variable regression; panel data;

JEL Code

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Introduction

Agricultural extension 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.

Garforth *et al* (2003) highlighted that most developed countries have established a form of advisory service for rural land managers funded largely from general taxation and delivered by public organisations. This form of public extension service has since been supplemented by the private sector but the overall aim of developing individual and collective performance of farmers and the farming sector can be viewed as an on-going objective of these organisations collectively. There are many challenges for the agricultural sector, such as the need to strike a balance between increased productivity to feed a growing global population and reducing negative environmental externalities including climate change. Extension services are important in these circumstances as they can act as levers to change existing behaviour in the wider agricultural and rural sectors. However, coupled with this responsibility is a financial challenge as global economies navigate the recent turbulent macroeconomic cycles and there is a renewed emphasis on 'value for money' policies. Thus, an evaluation of the impact of existing services is useful to ensure targeted efficient extension programmes are delivered into the future, thus, providing assistance in achieving targets set out in policies such as Food Wise 2025 in Ireland.

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 make changes on their farm to improve long term profitability. Similarly, Garforth et al. (2003) found participatory extension positively affected both technology adoption and profitability. This paper focusses on the latter construct by examining the relationship between extension engagement and farm income. More recently Dercon *et al.* (2009) also found a positive impact for extension engagement on poverty alleviation in Ehiopia by reducing headcount poverty by 9.8% and increasing consumer growth by 7.1%. These studies complement the findings of Anderson and Feder (2004) who also reviewed previous studies on impact, and whilst positive results are common, they warned that results should be treated with caution given econometric challenges.

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, 2014), 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. This paper extends on these previous studies in its focus by providing an aggregated impact evaluation of Irish public extension service, whilst adjusting for endogeneity and measurement error through instrumental variable regression.

Accordingly, there have been a limited number of attempts to quantify this economic return in an agricultural context, particularly through an instrumental approach. Cawley and Meyerhoefer (2012) utilised instruments in their analysis on the effects of obesity on medical costs and found that previous estimates grossly underestimated the costs by approximately 418% on average, as opposed to the IV approach. This underestimation was observed for all sub groups to various scales, but the policy implications are clear, subject to the generalisability of their results. Similarly Card (1999) showed increased impact of education on earnings once instrumental variables controlled for the estimation biases. In an agricultural context, Owens *et al.* (2003) found a positive relationship between extension and the value of crop production of approximately 15 per cent higher whilst also addressing endogeneity through fixed effects and observable ability. This paper adopts an instrumental approach to address these challenges and provides a more reliable and robust estimation on the causal effects of agricultural extension to farm level than previous work.

Therefore, to explore a causal relationship between advisory contact and farm income, it is important to address endogeneity concerns. For example, the omission of an ability measure could overestimate the true effect of extension on farm income. Conversely, measurement error is likely to underestimate the true effect of this relationship (Card, 1999). Another potential issue surrounds a self-selection bias with more capable farmers more likely to engage with extension services. These issues combined infer that any estimate of advisory contact on farm income could potentially be significantly biased.

This issue is often acknowledged in the literature, yet it is not commonly controlled for. Thus, accommodating an instrumental variable to overcome this problem would improve the robustness of the findings. 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 choice to engage in extension services. Identifying a valid instrument (a variable that is correlated with the decision to engage with advisory services, but not directly related to the dependent variable of farm income) is the key challenge. Given this precondition the distance from the local office and a policy change are chosen as suitable instruments in this case. The former variable is expected to negatively affect the decision to engage in extension services but uncorrelated with farm income. The latter is based on an exogenous policy shock where a new initiative incentivised farmers to engage with extension services, but did not affect their farm performance directly. Thus this paper aims to build on this research gap by applying an instrumental variable (IV) approach, where these instruments can 'purge' the endogenous regressors, and allow consistent coefficient estimates (Gabel and Scheve, 2007), thus identifying an empirical causal relationship between extension engagement and farm income.

Accordingly, this paper performs IV regression analysis using a pooled panel data set of Irish farms, and adopts extension contact, as the central explanatory variable to assess the impact on farm family income per hectare. The remainder of the paper is structured as follows: initially the theoretical context for extension services is outlined, along with the research hypotheses. This is followed by an overview of the methodology and data. Subsequently the results are discussed followed by the conclusion.

Theoretical Context and Research Hypotheses

In order to conduct the analysis, it is important to outline the theoretical context in which this research is addressed. Agricultural extension incorporates varied activities aimed at diverse objectives in a predominantly heterogeneous and complex sector. For example, 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, among other objectives.

Agricultural Extension

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, it is a service that transfers specialist knowledge to the producer with the aim of fulfilling a set objective whether from policy level or on a micro per farm basis. Birkhaeuser *et al* (1991) summarised the process of extension 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.

The theoretical contribution here focuses on the decision to participate in extension programmes and the resulting application of new knowledge and the impact on the farm level. The literature on knowledge management and transfer is dense in terms of organisations and firms, but is quite limited in terms of agricultural production. Leeuwis (2004) explored the role of extension in knowledge exchange activities and discussed the deep complexities that lie within. The heterogeneous preferences and learning styles of the farming community highlight the challenge for extension providers, and organisational management theories are inadequate to fully understand the process or type of extension provided. Therefore, when setting the research hypotheses it was imperative to recognise these difficulties and focus on a specific objective of intervention.

Why Intervene?

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, rural development, and innovation to name a few examples. Van den Ban and Hawkins (1988) argued that extension agents can 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. For example, an adviser must be familiar with the current developments in the sector to provide the 'insight' to the farmer as to imminent changing conditions. In other words, extension personnel need to respond to emerging challenges, and continue to provide valuable effective advice to farmers as issues have.

Policy

The Department of Agriculture manages the macro affairs of the Irish agricultural sector. However, on a micro basis there is demand of individual, group or regional assistance, and in this context extension programmes emerge. Thus, the department sets out the objectives and targets for the future (such as Food Wise 2025), and then the agricultural sector must adapt and improve to achieve these aims. Indeed Van Den Ban and Hawkins (1988) argued that there are two goals for a government with regard to agricultural extension; first to help farmers reach their goals as efficiently as possible, and secondly to change farmers' behaviour to achieve government goals. An efficient, flexible, functional extension body has the ability to complement this process by assisting at farm level, whether aimed at productivity, profitability, innovation, technology adoption, life skills or environmental mitigation.

Extension Services in Ireland

The extension service in Irish agriculture is led by both public and private consultants. Teagasc is the main body for the public delivery of agricultural research, advice and training since 1988, and this research is conducted from data referring to Teagasc clients only.

The Teagasc advisory service focusses on four particular 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 deliver on diverse farm level outcomes such as profitability, sustainability, biodiversity, diversification, innovation and technology adoption. This paper primarily focusses on the impact of the Business and Technology programme and the associated impact on farm level margins and income.

Impact of Extension – International Literature

Previous studies have attempted to quantify the impact of knowledge transfer activities in agriculture. Birkhaeuser *et al.* (1991) conducted a detailed overview of extension and reported high benefit-cost ratios for participation. However, reviews by Anderson and Feder (2004) asserted that the dominant theme was of variability across the results. More recently Davis *et al.* (2012) evaluated the impact of field schools in East Africa, and found that participation improved income and productivity, particularly for small-scale farmers in the region. However, they also found significant differences across gender, land resource endowment and level of education. Wang (2014) assessed the impact of extension in a US context, and although he highlighted difficulties with separating the benefits from R&D investments and the capacity of localities to implement extension effectively, found high rates of return to investment and a high benefit-cost ratio. In contrast, Hunt *et al.* (2014) found that the impact of extension services on productivity declined in Australia over time and the challenge to rectify this has emerged.

However, the extent to which these papers addressed the issue of endogeneity is varied and none listed above utilised an instrumental variable approach.

Impact of Extension – Irish Literature

In an Irish context Heanue and O'Donoghue (2014) found positive economic outcomes for the more educated farmers using an instrumental approach. O'Neill *et al*. (1999) also found that extension had a positive effect on farm level productivity. Läpple *et al*. (2013) found a positive relationship of €310 per hectare (12%) between dairy discussion group membership and gross margins utilising an endogenous switching model. Bogue (2014) evaluated the beef discussion group scheme run by Teagasc and found that on average, discussion group members had higher margins as well as increased profit, animal performance and grazing seasons. Additional benefits were identified due to enhanced management practices learned from the discussion groups, and that discussion group members were more likely to adopt emerging technologies and practices. Läpple and Hennessy (2014) explored the role of incentives of extension programs, and found that a monetary incentive did increase participation.

However, analysis into the impact of extension engagement on farm level outcomes across all systems is less common, and the application of instrumental variable regression to extension impact has not been researched in an Irish context, to the best of our knowledge at present.

Research Hypotheses

Thus, for the purpose of this research the ability of extension programmes to improve farm performance in terms of income is central. The key assumption is that farmers utilise advisory assistance to improve their profitability primarily, as opposed to alternative functions of extension such as environmental mitigation or scheme assistance. Thus, whether a farmer engaged with extension in the first instance, and subsequently the result of that engagement to these farm outcome measures is tested. A positive relationship is expected.

This research set out to address the following hypotheses:

1. Extension services positively impact farm level outcomes (family farm income) across all farming systems
2. The impact of extension on farm income is robust whilst addressing the issue of endogeneity

Methodology

Issues and Requirements

Birkhaeuser et al (1991) identify a number of problems associated with assessing the impact of knowledge transfer 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). In other words, the result of the coefficient for the endogenous variable will be biased as its magnitude is somewhat determined by the error term. It has three primary causes;

Firstly, and in our case, omitted variable bias causes an obvious problem for this analysis given that clearly, a farmer's ability, effort, ambition or their motivation would have an effect on the impact of extension engagement, yet we do not observed this data.

Secondly, self-Selection bias is a methodological error caused by initial differences between participants and non-participants to advisory services due to the conscious decision to enrol or not (Imbens and Wooldridge, 2009). 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 on the one hand to bolster their performance, or they may feel beyond help and investing in advisory services is not worthwhile. Thus, farmers using the service are systematically different than those who do not (Tamini, 2011, Hennessy and Heanue, 2012). Moreover, advisers themselves may influence this bias, indicating bidirectional causality, by actively seeking out clients they have built a prior relationship with or clients they feel can disseminate knowledge informally on their behalf to a wider audience, Conversely, they may avoid particular clients for various reasons such as location, personal characteristics or due to time constraints.

Finally, another form of bias may be related to measurement error. Given the endogenous variable for extension contact is imperfectly measured as a binary variable this is likely to cause a downward (attenuation) bias on the initial OLS estimation prior to instrumentation (Card, 1999, Wooldridge, 2002). 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.

These issues can be adequately addressed by applying an appropriate Instrumental Variable approach (Card, 1999, Cawley and Meyerhoefer, 2012, Howley *et al.* 2015). Murray (2006) argued that IV estimation can consistently estimate coefficients that will almost certainly be close to the coefficients true value if the sample is sufficiently large. However, this approach is dependent on the precondition of identifying suitable instruments.

IV Regression

Thus, the methodology of this research builds on Cards' (1999) influential work is that of instrumental variable regression analysis, to combat this well-recognised issue of endogeneity. Card focused on the economic returns to education using this approach, and in this paper we apply similar principle by substituting agricultural extension for education and controlling for endogeneity biases.

The assumption of the classical linear regression model in that the expected value of the total errors given the parameters is equal to zero, which is violated in this context (Heanue and O'Donoghue, 2014). Thus, an instrumental variable was implemented to counteract this bias. Murray (2006) explained that this instrument must be correlated with the endogenous explanatory variable (relevant), but uncorrelated with the dependent variable and error term (valid).

The process involved a two stage regression, where firstly the instrument(s) was regressed on the endogenous variable, and subsequently the predicted value of the variable was inserted into the main structural equation. If such an instrument can be found, then an unbiased consistent coefficient for the endogenous variable can be estimated (Gujarati 2003).

Selection of Instruments

Accordingly, the primary challenge for IV analysis is identifying a suitable instrument that meets these dual requirements of correlation with the endogenous regressor and the more challenging exogeneity and exclusion restrictions.

Murray (2006) noted that having at least as many instruments as troublesome 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 one endogenous variable. The distance to the local advisory office and the policy change effect of the introduction of the Single Farm Payment in 2005 where chosen on the basis of previous literature. Card (1999) utilised geographic proximity to school and Callan and Harmon (1999) along with Heanue and O'Donoghue (2014) used a policy change as an exogenous shock. Moreover, intuitively 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 rational for both instruments is explained in the subsequent section.

Functional Form of Model

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:

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

where y_2 is our endogenous regressor (advisory contact), π_j is our estimated parameter coefficients, z_k are our instruments, $\boldsymbol{X}$ is a vector of all other explanatory variables and $\boldsymbol{v_2}$ 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:

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

where $y_1$is the unbiased estimation of our dependent variables, β_j is our estimated parameter coefficients, y_2 is our 'purged' endogenous variable, $\boldsymbol{X}$ is a vector of all other explanatory variables and $\boldsymbol{u_1}$ is our error term.

Specification Tests

In the first stage regression, 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. Howley *et al.*, (2015) cited this as the standard overidentification test to test the validity of the instruments and asserted it as a benefit of the 2SLS approach. Indeed Cawley and Meyerhoefer

(2012) noted that proving the null hypothesis of no effect is impossible, and therefore doubt will remain, but application of the Sargan test (or Hansen Test when controlling for heteroscedasticity) of validity and failure to reject means the instruments cannot be proven as invalid, which bolsters the argument of validity for the chosen instrument. 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 not valid (Gujarati 2003). All specification tests are reported in the results.

Data

Data Requirements

In order to test the research hypotheses, particular data was required. Firstly, it was important to observe participants and non-participants in extension programmes. This was selected as the basis of our endogenous variable. A binary variable was established based on any form of advisory contact with Teagasc or none at all. While this value is imperfect in the sense of not incorporating more intensive forms of engagement, it does provide an initial aggregated value of extension which can be tested.

In relation to farm level outcomes, income is a useful barometer of performance levels, particularly over time. Thus, farm family income was observed which included the subsidy effect. Furthermore, additional factors influence farm income, such as the location, farm system and other characteristics so they were included. This data was obtained for the Teagasc National Farm Survey (NFS).

Data Description

The data used for the analysis is from the Teagasc National Farm Survey (NFS), which is an annual panel data source collected as part of the Farm Accountancy Data Network of the European Union. It consists of approximately 1,100 farms per annum. The Teagasc NFS 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 observation 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, the sample focused on Teagasc clients only, and therefore does not account for farmers who engage with private consultants. Furthermore, given the policy change in 2005, the sample selected prioritised farmers who were in the sample prior to the introduction of that policy change, but were not Teagasc clients initially. In other words, this analysis pools the panel data set to observe the average effects on farm income for new clients only. This refines the sample, by ensuring we focus on a similar group of farmers who were only motivated to become clients subsequent to the policy change. Including the full sample increases the variation in the results due to inclusion of commercially driven farmers who may have self-selected into extension services regardless of the policy change. Analytical weights were assumed for each observation so the final sample is nationally representative. Accordingly, the final sample size across the 14 years selected is 8,951 for the models estimated.

Dependent Variable

The dependent variable chosen for the analysis was family farm income, which was divided by utilisable hectares to obtain a more representative ‘per hectare’ indicator. Family farm income is defined as gross output less net expenses (direct and overhead) and includes subsidy receipts. This gives a more wholesome portrayal of the overall income attributable to the farm household. 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 would receive a financial gain directly attributable to this process in a given year. However, as the payment was decoupled under the CAP reform, this subsidy effect would not vary over time, and thus differences in farm income would be based other factors associated with farm performance.

Independent Variables

The main independent or explanatory variable selected for the regression analysis was advisory contact 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, the impact of engagement can be evaluated with the dependent variable based on this aggregated measure.

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. Summary statistics of all variables are provided in Table 1.

Instruments

Two instruments were identified based on previous literature and intuitive reasoning. These variables must affect the decision to participate in extension (our endogenous explanatory variable) but not directly affect farm income (dependent variable) after controlling for various other exogenous variables (other independent variables included) as argued above.

The first was based on the distance as previously utilised by Card (1999). In this case the distance to the local advisory office was expected to negatively influence the decision to participate in extension services, but not to affect personal characteristics of the farmer such as their innate ability or motivation. Thus, it was expected to be correlated with the endogenous regressor (advisory contact) but exogenous to the omitted variables contained in the error term. For example, a farmer located a significant distance from a local office may not choose to engage, but this distance is unlikely to affect his farming capabilities or farm performance. Moreover, the location of farm in Ireland is largely due to inheritance as opposed to the choice of where to locate, and thus the distance to a local office is largely exogenous, thus uncorrelated with the error term. This instrument was calculated by measuring the geographic distance from each observation to the nearest advisory office, which is available in the Teagasc NFS.

The second instrument was due to the policy shock caused by the introduction of the Single Farm Payment Scheme in 2005, which replaced previous coupled payment schemes with an average decoupled payment based on an average calculated over a historical reference period (2000-2002). 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 affect farmer ability or motivation, again contained in the error term. Furthermore 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. Furthermore, it is not expected to affect the dependent variable, as although the single farm payment is included in farm family income, as the payment is flat annually, any variation in farm income must be due to other factors. This binary variable was developed by assigning a value of 1 if the year was after 2005 and a 0 if before.

Finally these instruments were interacted to examine the impact of distance given the policy change. In other words, was the effect of distance less influential once the new policy was introduced in the decision to participate in extension? It is expected that it would remain a negative relationship but not as pronounced in magnitude. This addition helped to improve the functional form and robustness of the final model.

Murray (2006) and Cawley and Meyerhoefer (2012) warned to be cautious with regard to the validity of instruments, but formulating a strong argument in their favour is helpful. Intuitively 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 argue that the instruments applied are effective in combating endogeneity in the results.

Data Preparation

The dependent variable was transformed using its natural logarithms to remove the influence of outliers in the sample, to smooth the distribution of the data and to interpret our coefficients as percentages. Data on advisory contact was available from 2000 so years previous were not included in the analysis. Advisory contact was collected as a binary variable with a value of 1 if any level of participation and 0 otherwise. Various control explanatory variables were included on the basis of expected effects on the dependent variable. These controls also strengthen our instruments exogeneity condition, as each control reduces the effect of the error term on the instruments.

Summary Statistics

The following table presents the summary statistics for variables included in the analysis:

Table 1. Data Description and Summary Statistics

Variable	Description	Mean	SD	Min	Max
Dependent Variable					
FFI/ha	Family farm income per ha	456.6	434.5	-1798	3572
Ln FFI/ha	Log of family farm income per ha	5.919	0.939	-1.627	8.181
Endogenous Variable					
Advisory Contact	= 1 if Teagasc client	0.535	0.499	0	1
Controls					
Ln Land Value/ha	Log of land value per ha	-0.112	0.563	-4.793	2.606
Farm Size	No. of utilisable hectares	38.03	34.55	2.8	1117
Stocking Density	Total Livestock Units per ha	1.355	0.632	0	4.797
Ln Labour	Log of unpaid family labour	-0.055	0.510	-4.605	1.428
Age	Age of farmer	55.13	12.22	17	90
Years Agri ed	= .5 if short course ; = 2 if ag cert; = 4 if ag university	0.677	0.984	0	4
System:					
Dairy	= 1 if dairy	0.116	0.321	0	1
Dairy & Other	= 1 if dairy & other	0.072	0.259	0	1
Cattle Rearing	= 1 if cattle rearing	0.173	0.378	0	1
Cattle Other	= 1 if cattle other	0.203	0.402	0	1
Mainly Sheep	= 1 if mainly sheep	0.124	0.330	0	1
Tillage	= 1 if tillage	0.046	0.210	0	1
Region:					
Border	= 1 if farm is in the border region	0.201	0.401	0	1
Dublin	= 1 if farm is in the Dublin region	0.012	0.103	0	1
East	= 1 if farm is in the east region	0.086	0.280	0	1
Midlands	= 1 if farm is in the midlands	0.105	0.307	0	1
Southwest	= 1 if farm is in the southwest	0.096	0.295	0	1
Southeast	= 1 if farm is in the southeast	0.138	0.345	0	1
South	= 1 if farm is in the south region	0.178	0.383	0	1
Medium Soil		0.3978	0.4895	0	1
Poor Soil		0.1232	0.3287	0	1
Instruments:					
Dist_advoff	Distance to advisory office (km)	10.71	8.626	0	62.16
SFPyr	= 1 if advisory client after 2005	0.657	0.475	0	1
SFPYR*Dist	Interactive term for clients and distance	7.395	9.156	0	62.16

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

Results (Preliminary)

The results of the econometric models are presented in this section. Given that Ordinary Least Squares (OLS) estimation is expected to bias the results due to the endogeneity problem, the superior IV approach is the focus. However, the OLS estimates are also presented in Table 3 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 diagnostic statistics. Thus, in total four models were estimated, one using OLS, and three using IV with one, two and three instruments added respectively. These results are presented in the following subsections based on the two stage least square results.

IV results – First stage results

The results of the first stage of the IV process are presented in Table 2, outlining the relevance of the instruments on advisory contact decisions.

Table 2. First Stage Results of IV: Advisory Contact and Annual Contracts

	1 Instrument		**2 Instruments**		**3 Instruments**	
Advisory Contact	**Coeff. (SE)**	**p value**	**Coeff. (SE)**	**p value**	**Coeff. (SE)**	**p value**
SFP Policy Δ	.5304 (.0103)	.000	.5310 (.0103)	.000	.5650 (.0156)	.000
Dist. Adv Office			-.0022 (.0005)	.000	.0005 (.0011)	.649
Interaction Term					-.0035 (.0012)	.004
CD Wald F Stat	2639.2		1331.9		891.4	

note: endogenous regressor (Advisory Contact), 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 (Value of >10 assumed as strong relevance)

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 95 local Teagasc offices in existence before a restructuring plan introduced in 2009. Thus the average distance was 10.34 km before the closures and only increased to 11.8 km afterwards. 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. Stock *et al.* (2002) ascertained that a first stage F statistic must be large and typically exceed a value of 10 to be deemed a strong instrument. In our case, this limit is easily exceeded and we can conclude that the instruments are relevant.

IV results – Second stage results

The second stage of the IV process involves inserting the predicted values of the endogenous regressors 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 variables of interest are presented in table 3 for clarity with the full table of results available in Appendix A. The OLS estimates are also included for comparison.

Table 3. IV parameter estimates: Model of Log of Farm Family Income per Ha

	OLS	**IV – 1 Instrument**	**IV – 2 Instruments**	**IV – 3 Instruments**
Advisory Contact	.1924*** (.0197)	.3500*** (.0414)	.3491*** (.0412)	.3456*** (.0412)
R^2	.2222			
Centred R^2		.2167	.2167	.2170
Sargan p value		.000	.8108	.2966

*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 the appendix; 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*

The results presented here show that there are consistent positive returns to engaging in extension services, and all are significant across all models. The OLS results indicate a 19 per cent increase in farm family income per hectare ceteris paribus. However, as this variable suffers an endogeneity bias, the coefficients estimated for the IV models are a more accurate prediction, and as evidenced in the table, this return is approximately 35 per cent across the three models with instruments added cumulatively. The consistency of the estimates justifies the validity of the estimates as being strong predictors of extension participation and thus instrumenting it successfully to identify the causal impact of participation on farm family income per hectare.

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 not possible 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 our null is that the instruments have an effect, and in this case we fail to reject that claim. In other words, these instruments address the endogeneity issue from extension participation, and thus our estimates provide a consistent and positive impact on farm family income per hectare.

Given the results of the analyses both hypotheses have not been rejected, and thus, extension services had a positive impact on farm income.

Conclusions and Policy Impact

While much of the previous literature has identified a positive relationship between extension services and farm level outcomes, their findings are prone to questioning based on endogeneity concerns. The IV modelling approach presented here appropriately addresses these issues by applying the ‘two stage least squares’ method. The results indicate that the positive relationship may have been underestimated given the coefficients estimated in this paper. In line with previous literature the IV estimates of the impact of extension services are uniformly higher than the OLS estimates (Card 1995, Cawley and Meyerhoefer 2012). Therefore there is a clear indication of a net benefit to extension engagement in the first instance.

Identifying a valid instrument is a critical challenge of the IV approach, particularly in terms of proving the exogeneity to the error term, and thus should be interpreted with caution (Cawley and Meyerhoefer, 2012). However, in this analysis the instruments chosen were relevant and valid based on intuitive reasoning 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 here suggest there is a causal positive effect of participating in extension programmes in terms of farm income. Thus, a more targeted approach may be valuable, that incentivises engagement based on the benefits as shown here. Therefore, the targets set for the agricultural sector by government under the Food Wise 2025 strategy and Teagasc's own Foresight 2030 programme should be adequately supported by a dynamic effective extension programme.

Limitations and Further Research

This paper 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 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, and this would not have directly affected their farm income. Similarly, the availability of advisers could have been a useful instrument given the drop in numbers due to retirements reducing the availability of services. However, both of these were not possible due to data limitations.

Moreover, the distance to advisory office instrument could prove more effective if the offices were dependent on the types of services offered, as smaller offices may not have the facilities to address more intensive forms of extension contact. Concurrently, as the endogenous variable here is adopted as a dummy and thus does not reflect the variability of extension services available, and thus, to rigorously distinguish different types of extension contact and assess their impact would enrich the analysis further. Indeed, for the policy change instrument, identifying the specific service adopted would clarify the purpose for engagement. Thus, further research into these areas and also examining the process of how knowledge is transferred successfully in terms of famer learning or organisational behaviour would enrich the findings presented here.

Moreover, Coccia (2008) stated that knowledge impact is not homogenous, but more likely to be heterogeneous in nature. Thus, future research should aim to identify the impact at different levels as opposed to the average.

This paper sets the stage for follow up papers that distinguish the type and extent of advisory contact in much more specific detail, and account for the changing personnel and facilities that were available to implement knowledge transfer strategies.

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Appendix A – Full table of OLS and IV estimates

	Coeff	SE	p	Coeff	SE	p
	OLS Regression			Instrumental Variable Regression – 1 Instrument		
Has Advisory Contact	0.1924	0.0197	0.000	0.3500	0.414	0.000
Log Land Value per Ha	0.1513	0.0202	0.000	0.1464	0.0203	0.000
Dairy System	0.3425	0.0340	0.000	0.3670	0.0345	0.000
Dairy and Other System	-0.0902	0.0404	0.025	-0.0575	0.0412	0.163
Cattle Rearing	-0.1887	0.0298	0.000	-0.1477	0.0314	0.000
Cattle Other System	-0.1932	0.0278	0.000	-0.1560	0.0292	0.000
Mainly Sheep	-0.0756	0.0330	0.022	-0.0300	0.0347	0.387
Tillage	0.2620	0.0501	0.000	0.2861	0.0505	0.000
Log of Family Labour (unpaid)	-0.1457	0.0224	0.000	-0.1449	0.0224	0.000
Age	0.0088	.0058	0.129	0.0102	0.0058	0.081
Age Squared	-0.0001	0.0001	0.106	-0.0001	.0001	0.060
Has off farm employment	-0.1207	0.0226	0.000	-0.1254	0.0226	0.000
Log Farm Size	0.0207	0.0168	0.217	0.0028	0.0173	0.870
Has Forestry	-0.0532	0.0432	0.218	-0.0860	0.0439	0.050
Completed Agricultural Short Course	0.2233	0.0298	0.000	0.2100	0.0300	0.000
Completed Agricultural Certificate	0.2012	0.0264	0.000	0.1803	0.0269	0.000
Completed Agricultural University	0.2457	0.0623	0.000	0.2353	0.0624	0.000
Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth	-0.1324	0.0296	0.000	-0.1336	0.0297	0.000
Dublin	-0.2091	0.0816	0.010	-0.2066	0.0817	0.012
Kildare, Meath, Wicklow	-0.1778	0.0403	0.000	-0.1846	0.0404	0.000
Laois, Longford, Offaly, Westmeath	-0.1667	0.0384	0.000	-0.1448	0.0388	0.000
Clare, Limerick, Tipp. N.R.	0.0055	0.0353	0.876	0.0157	0.0354	0.658
Carlow, Kilkenny, Wexford, Tipp S.R., Waterford	-0.1537	0.0359	0.000	-0.1713	0.0362	0.000
Cork, Kerry	0.0007	0.0314	0.981	0.0018	0.0315	0.953
Galway, Mayo, Roscommon (omitted)						
Stocking Density	0.4185	0.0186	0.000	0.4049	0.0189	0.000
Medium Soil	-0.0747	0.0215	0.001	-0.0763	0.0216	0.000
Poor Soil	-0.0098	0.0329	0.765	-0.0298	0.0333	0.370
Constant	5.0830	0.1696	0.000	5.0517	0.1701	0.000
Number of Observations	8,951			8,951		
Centred R2	0.2222			0.2167		
Cragg-Donald Wald F Statistic (Weak Instrument)				2639.2		
Sargan statistic p value (Overidentification Test)				0.000		

note: endogenous regressor (Advisory Contact); 1 instrument (Single Farm Payment year policy change); additional explanatory variables included, land value, farm system, labour, size, off farm job, age, region, stocking density & soil group; Stock et al. (2002) argue Wald F Statistic <10 considered weak; Sargan Statistic void due to equation exactly identified

	Coeff	SE	p	Coeff	SE	p
	Instrumental Variable Regression – 2 Instruments			Instrumental Variable Regression – 3 Instruments		
Has Advisory Contact	0.3491	0.0412	0.000	0.3456	0.0412	0.000
Log Land Value per Ha	0.1464	0.0203	0.000	0.1465	0.0203	0.000
Dairy System	0.3669	0.0345	0.000	0.3663	0.0345	0.000
Dairy and Other System	-0.0576	0.0411	0.161	-0.0584	0.0411	0.156
Cattle Rearing	-0.1479	0.0313	0.000	-0.1488	0.0313	0.000
Cattle Other System	-0.1562	0.0292	0.000	-0.1570	0.0292	0.000
Mainly Sheep	-0.0302	0.0346	0.383	-0.0313	0.0346	0.367
Tillage	0.2860	0.0505	0.000	0.2855	0.0505	0.000
Log of Family Labour (unpaid)	-0.1449	0.0224	0.000	-0.1449	0.0224	0.000
Age	0.0102	0.0058	0.082	0.0101	0.0058	0.083
Age Squared	-0.0001	0.0001	0.060	-0.0001	0.0001	0.061
Has off farm employment	-0.1254	0.0226	0.000	-0.1253	0.0226	0.000
Log Farm Size	0.0029	0.0173	0.866	0.0033	0.0173	0.848
Has Forestry	-0.0859	0.0439	0.051	-0.0851	0.0439	0.053
Completed Agricultural Short Course	0.2101	0.0300	0.000	0.2104	0.0300	0.000
Completed Agricultural Certificate	0.1805	0.0268	0.000	0.1809	0.0268	0.000
Completed Agricultural University	0.2354	0.0624	0.000	0.2356	0.0624	0.000
Donegal, Leitrim, Sligo, Cavan, Monaghan, Louth	-0.1336	0.0300	0.000	-0.1335	0.0297	0.000
Dublin	-0.2066	0.0817	0.011	-0.2066	0.0817	0.011
Kildare, Meath, Wicklow	-0.1846	0.0404	0.000	-0.1844	0.0404	0.000
Laois, Longford, Offaly, Westmeath	-0.1450	0.0388	0.000	-0.1454	0.0388	0.000
Clare, Limerick, Tipp. N.R.	0.01563	0.0354	0.659	0.0154	0.0354	0.664
Carlow, Kilkenny, Wexford, Tipp S.R., Waterford	-0.1712	0.0362	0.000	-0.1708	0.0361	0.000
Cork, Kerry	0.0018	0.0315	0.953	0.0018	0.0315	0.954
Galway, Mayo, Roscommon (omitted)						
Stocking Density	0.4049	0.0189	0.000	0.4053	0.0189	0.000
Medium Soil	-0.0763	0.0216	0.000	-0.0763	0.0216	0.000
Poor Soil	-0.0297	0.0333	0.371	-0.0293	0.0332	0.379
Constant	5.0518	0.1701	0.000	5.0526	0.1701	0.000
Number of Observations	8,951			8,951		
Centred R2	0.2167			0.2170		
Cragg-Donald Wald F Statistic (WeakInstrument)	1331.9			891.		
Sargan statistic p value (Overidentification Test)	0.8108					

note: endogenous regressor (Advisory Contact 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); additional explanatory variables included land value, farm system, labour, size, off farm job, age, region, stocking density & soil group; Stock et al. (2002) argue Wald F Statistic <10 considered weak; Sargan Statistic for overidentification p value > 0.1 fails to reject null hypothesis of instruments validity