Rural Economy & Development Programme

The Economic Returns to Formal Agricultural Education

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Agriculture and Food Development Authority

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Contents

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1.0 Executive Summary

1.1 Background

Irish farmers face a future of challenges and opportunities. Contributing to the grand challenge of sustainably delivering world food security; achieving the expansion and development targets set out in Food Harvest 2020; and, being able to produce efficiently and profitably in a market environment which includes the abolition of milk quotas and the opening up of markets for beef on the positive side, but with the possibility of increased price and income volatility on the negative side, are just some of the contextual factors. However, there is widespread and long-standing agreement that it is in such a rapidly changing technological and economic environment that agricultural education is most important.

This study focuses on the economic returns to formal agricultural education in Ireland. It presents two broad categories of evidence; descriptive data and the results of econometric analysis. That farmers themselves recognise that positive returns exist is evident from the increased demand for agricultural education courses. The benefits of formal agricultural education are clear: agricultural education improves a farmer's technical efficiency (the more efficient use of a given amount of resources) and allocative efficiency (choice of better inputs and outputs, leading to a more efficient allocation of resources). There are three main reasons why formal agricultural education improves technical and allocative efficiency.

1) Education by helping farmers make better use of information and find solutions to problems makes them better managers allocating their resources more efficiently.

2) Not only does education help farmers use existing information more competently but they also have better access to required information.

3) Educated farmers are more likely to adopt new technologies or products early because of their access to information and their ability to better distinguish between promising and unpromising innovations.

1.2 Findings

The analysis in this study is based on Teagasc National Farm Survey data for the period 2000 to 2011. The descriptive part of the study shows that over that period the percentage of farmers with a formal agricultural education increased from 24% to 44%, with a greater increase in the proportion of farmers achieving an agricultural certificate, going to agriculture college or attending short courses compared to those achieving university level agricultural training. In the dairy, tillage and mixed livestock systems, the proportion of farmers with a formal agricultural qualification exceeds the average, whereas for the cattle rearing and cattle other systems, it is below average. Family farm income is highest in those households where the farmer has either an agricultural certificate or has gone to agricultural college. Furthermore, income in the former households increased more over the period. Farmers with formal agricultural education tend to have larger farms and over the period they were consistently between 1.6 and 1.9 times larger than those farmers without formal agricultural education. Formally educated farmers have higher average gross margins per hectare: typically, average gross margins per hectare were between 1.3 and 1.7 times higher than those farmers with no formal agricultural education.

The first piece of analysis estimates the internal rate of return (IRR) to education investment. The IRR is the discount rate that equates the present value of benefits from an agricultural education to the present value of the costs of gaining that education. The rate of return can be viewed from the perspective of the farmer (private returns) and from society (social returns). For a student or their family, they will focus on costs and benefits that apply to the student in terms of foregone earnings, course fees and returns in terms of income. This is known as the *private rate of return*. From the perspective of the state, the benefits relate to the impact on output and other income streams relative to the total cost of providing the education. This is known as the *social rate of return*. The results confirm a high private return to investment in agricultural education (8.8%). In addition, there is a high social return to investment in agricultural education at farm level (13.4%), which rises to 24.5% when the wider supply chain impact is factored in. The results compare favourably with returns to other types of education.

In a more formal logistic regression analysis, the factors that influence the participation of farmers in formal agricultural education are examined. In terms of attending an agricultural college, farm scale factors (total livestock units, forage area, size of farm) all impact positively on attendance as do higher land values. Furthermore, farmers in counties other than Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan are more likely to attend college. Distance to college and age negatively impact on the probability of attending agricultural college. Of specific concern here was to see whether a farmer who was 35 years of age before 1994 (when Stamp Duty Exemption for young farmers was introduced) is less likely to engage in formal agricultural education. Moreover, farmers with good or medium quality soils are less likely to attend agricultural college, perhaps a reflection that more

productive farmers might decide not to pursue a formal agricultural education.

In terms of participation in an agricultural certificate, similar to the first model, the effect of being older than 35 in 1994 is negative. However, in contrast to the first model, there is a significant positive effect of distance from an agricultural college and participation on an agricultural certificate course. This could be interpreted as follows: farmers who are further away from an agricultural college substitute an agricultural certificate delivered locally in a Teagasc Regional Education Centre as their preferred formal agricultural education qualification. In relation to the other variables, in contrast to the first model, higher land values, total livestock units, age and forestry on the farm are not significant variables explaining participation in an agricultural certificate course. Being a Teagasc client and participating in a REPS scheme has a positive and significant effect on undertaking an agricultural certificate. Farmers in counties other than Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan are more likely to participate in an agricultural certificate and again, farmers with good or medium quality soils are less likely to participate in an agricultural certificate.

The next tranche of formal analysis, utilising a random effects panel model, shows that agricultural education has a significant and positive impact on family farm income. There is a well-known methodological issue of endogeneity associated with trying to identify returns to education. Following best international practice, in this study, the endogeneity problem is addressed by using an Instrumental Variable (IV) approach. Similar to many international studies on returns to education, this study uses distance to college and policy reform as two key instrument variables. The analysis confirms that these are appropriate to use in this context. The IV analysis confirms that when endogeneity is accounted for the impact of formal agricultural education on family farm income is positive.

The final piece of analysis, based on system level production functions, examines the pathways through which farm income is impacted, i.e. increased yields and intensity at farm level, and confirms that these are positively and significantly impacted by formal agricultural education. This is consistent with expectations from the literature on the positive link between agricultural education and technical and allocative efficiency. More specifically, within dairying, both yields and intensity are positively affected by attending agricultural college and achieving an agricultural certificate. For the cattle farming systems, both yields and intensity are positively affected by attending agricultural college, achieving an agricultural certificate and attending short courses. In sheep systems, intensity is positively impacted by attending agricultural college, achieving an agricultural certificate and attending short courses. Data shortcomings made it difficult to carry out the analysis for tillage systems.

In conclusion, this study focuses on identifying the economic returns to formal agricultural education for Irish farmers. The analysis confirms a positive and significant return both in terms of the internal rate of return from a human capital perspective but also clarifies the internal returns from agricultural education to farm level yields, intensity and income when viewed from a production function perspective.

The analysis confirms patterns in the international literature on returns to education.

2.0 Introduction

Irish farmers face a future of challenges and opportunities. Contributing to the grand challenge of sustainably delivering world food security; achieving the expansion and development targets set out in Food Harvest 2020; and, being able to produce efficiently and profitably in a market environment which includes the abolition of milk quotas and the opening up of markets for beef on the positive side, but with the possibility of increased price and income volatility on the negative side, are just some of the contextual factors. However, there is widespread and long-standing agreement that it is in such a rapidly changing technological and economic environment that agricultural education is most important for increasing agricultural production and improving returns to farmers (Schultz 1975; Ali and Byerlee 1991).

Notwithstanding any policy-driven rationale in terms of preferential taxation treatment and/or additional CAP-based payments, that farmers themselves recognise positive returns from agricultural education is evident from the increased demand for agricultural education courses. For example, first preference applications to the CAO for Agriculture and Veterinary courses increased by 31% between 2010 and 2014. In recent years, Teagasc has experienced more than a doubling of student enrolments for its flagship agricultural and educational programmes. In addition, uptake of its part-time courses, which are delivered through its 12 Regional Education Centres and its e-learning courses, has also expanded as has enrolment in third-level programmes, which are mostly delivered in partnership with the Institutes of Technology. Such is the demand that some students are unable to obtain education places: Browne (2011) estimated that in 2009/10, 230 students who wished to do so could not obtain a place on one of Teagasc's college courses

This growth in the human capital of the agricultural sector is a key aspect of the 'smart' agenda set out in Food Harvest 2020. In a recent review of the international literature, Reimers and Klasen (2011) outline three main reasons why formal agricultural education impacts positively on rates of return.

1) Education by helping farmers make better use of information and find solutions to problems makes them better managers allocating their resources more efficiently.
2) Not only does education help farmers use existing information more competently but they also have better access to required information.
3) Educated farmers are more likely to adopt new technologies or products early because of their access to information and their ability to better distinguish between promising and unpromising innovations.

This study sets out to identify the economic impact of formal agricultural education on returns for Irish farmers. It does this by presenting descriptive data but also the results of econometric analysis. Although formal agricultural education is often included as an explanatory variable in analysis of farm level behaviour and outcomes, it is not often the central focus of the research. Clearly, farmers engage in informal as well as formal education processes. Participation in informal education activities such as discussion groups, farm walks, open days, targeted courses (e.g. REPS), seminars and conferences are just some examples. The impact of many of these informal education activities on farmers' knowledge and skills is assessed by Teagasc either on an on-going basis, or as discrete once-off evaluations (e.g. Bogue, 2013).

The remainder of the document is structured as follows. Section 3 contains a literature review. Section 4 provides context in terms of an overview of formal agricultural education courses and provision. This section also reviews pertinent policy instruments, the data used in the ensuing analysis and the methodological approach to the analysis. Section 5 provides a descriptive overview of some aspects of the relationships between formal agricultural education and the farming population. Section 6 presents the internal private and social rates of return to investment in agricultural education. Section 7 examines the factors that influence the participation of farmers in formal agricultural education. Section 8 outlines the impact of formal agricultural education on family farm income and section 9 presents analysis of the impact of formal agricultural education on farm level yields and intensity, which are key drivers of farm income. Section 10 contains a brief conclusion.

3.0 Literature review

In reviewing the literature on the returns to formal agricultural education five key themes emerge. This study focuses on the first and second of these themes, with theme 3 confirming the importance of the current and future changing context for Irish agriculture. The language in the first and second themes is slightly confusing. The first theme arises from the literature on human capital. In this literature, education is viewed as an investment and, therefore, the internal rate of return is the discount rate that equates the present value of benefits from an agricultural education to the present value of the costs of gaining that education. By contrast, in the second theme the discussion on internal returns to agricultural education derives from a production level focus where the literature seeks to identify links between agricultural education and farm level productivity, efficiency, technology adoption and income.

1) The internal rate of return to investment in agricultural education
2) The internal returns to agricultural education
3) The external returns to agricultural education
4) The role of agricultural education in rapidly changing technological environments
5) The effect of agricultural education on occupational choice

3.1 Internal rate of return to investment in agricultural education

Much of the economic research on the value of educational investment stems from the work of Becker (1962) who introduced the concept of treating investment in education as a capital investment. From this human capital perspective, the challenge is to estimate the internal rate of return (IRR) to education investment. The IRR is the discount rate that equates the present value of benefits from an agricultural education to the present value of the costs of gaining that education. The rate of return can be viewed from the perspective of the farmer (private returns) and from society (social returns). For a student or their family, they will focus on costs and benefits that apply to the student in terms of foregone earnings, course fees and returns in terms of income. This is known as the *private rate of return*. From the perspective of the state, the benefits relate to the impact on output and other income streams relative to the total cost of providing the education. This is known as the *social rate of return*.

It is difficult to compare studies on the internal rate of return to formal agricultural education. However, there is a large comparable literature on returns to education more generally. Based on a meta-analysis of returns to education studies, Harmon et al. (2003) identify an average return of around 6.5% across a range of countries and model specifications. Although Nordic countries generally have lower returns to education, the UK and Ireland report higher than average returns at 8% and 9.5% respectively.

3.2 Internal returns to agricultural education

The analysis of internal returns to agricultural education focuses on how agricultural education augments various aspects of farm level productivity, efficiency or income. There are several distinct aspects to the internal returns to agricultural education literature. These include technical and allocative efficiency and innovation and technological change.

Technical and allocative efficiency

Internal returns relate to the farm/farmer and are manifest in increases in productivity, efficiency, technology adoption, innovation or income at farm level. In a seminal contribution, Welch (1970) identifies the benefits of agricultural education as the 'worker effect' and the 'allocative effect'. The worker effect is conceptually equivalent to what later commentators have called 'technical efficiency' (Azhar, 1991) and describes how a farmer is able to *use a given amount of resources more efficiently*. The allocative effect is where a farmer has the ability to acquire and use information about the cost and productive potential of other inputs; this leads to *a choice of better inputs and outputs*. As a result, the educated farmer uses a different mix of inputs compared to other farmers; in other words (s)he allocates and uses resources more efficiently. It is argued that the main benefit of farmer education is as a consequence of the allocative effect and only a limited extent from the worker effect (Reimers and Klasen, 2011; Huffman, 1999).

It is useful to get a better understanding of the processes underpinning how allocative and technical efficiency arise and how education supports those processes. The classic contributions of Nelson and Phelps (1966) and Schultz (1975) are useful for understanding the role of education in these processes, and Reimers and Klasen (2011) have succinctly collated them into the following:

1) Education by helping farmers make better use of information and find solutions to problems makes them better managers allocating their resources more efficiently.
2) Not only does education help farmers use existing information more competently but they also have better access to required information.

3) Educated farmers are more likely to adopt new technologies or products early because of their access to information and their ability to better distinguish between promising and unpromising innovations.

There is little existing Irish evidence on the returns from formal agricultural education in terms of productivity, efficiency and income.

Innovation and technological change

The role of education in technological change and innovation is reflected in two classic contributions to the literature. In the adoption and diffusion of innovation literature spawned by Rogers (1962) and Griliches (1957), 'innovators' or 'early movers' are those farmers who first take up a technology and, therefore, start the diffusion process. Education supports such farmers to make these decisions in several ways:

1) As education decreases risk aversion the probability of adoption and innovation is increased (Knight et al. 2003).

2) Formal education is more likely to make farmers take the initiative in the adoption of innovations, either by introducing new ideas themselves or being the first to copy a successful innovation (Weir and Knight**,** 2004).

3) Adoption decision-making among farmers is a human capital intensive activity and education and information reduce adoption costs and uncertainty, and thereby raise the probability of early adoption (Wozniak, 1987).

Elsewhere, and relatedly, Schultz (1975) in a seminal contribution argues that the benefits of education to farmers are especially important in times of disequilibria, i.e. when there is pervasive and rapid technological change. In this case, education can help farmers respond more efficiently to disequilibria. The corollary to this is that the returns to education should be higher in societies experiencing greater technical progress.

There is some existing Irish evidence on returns to agricultural education in terms of technological/practice change and innovation. Farmers who have completed formal agricultural education are 13% more likely to be prepared to grow GM crops (Keelan et al. 2009); are 3 times more likely to voluntarily soil test than those farmers without formal agricultural education (Kelly 2014); reseed more than 12% of their land in the past 3 years (Heanue and Buckley, 2012) and are 6% more likely to consider growing bioenergy crops (Clancy et al 2011).

3.3 External returns to agricultural education

There are other strands to the agricultural education literature. For example, it is acknowledged that not only may there be internal returns to the individual farmer from agricultural education (as discussed above), but there may also be external returns or benefits that accrue to those with whom the educated farmer interacts (Weir and Knight, 2004). In this case informal learning occurs as farmers copy their more productive (and perhaps more educated) neighbours (Weir and Knight, 2004). Here the evidence is mixed with some studies showing positive 'education externalities' or 'learning spillovers' (Foster and Rosenzweig, 1995) with other analysis in this vein failing to find any external effects (e.g. Asadullah and Rahman, 2009). Analysis of any such broader external effects is not considered as part of the present study.

3.4 The role of agricultural education in rapidly changing technological environments

There is a strong theme running through the literature that education plays a greater role in modernising rather than traditional agriculture. As mentioned previously, the argument is that education provides farmers with the capability to deal with the disequilibria caused by technological change and, therefore, educated farmers adjust more successfully (Schultz 1975; Ali and Byerlee 1991). Nelson and Phelps (1966) argue that the rate of return to education is greater the more technologically progressive is the economy. They argue that this finding has two social policy implications in terms of the optimal capital structure in a society in a broad sense. First, it may be that society should build more human capital relative to tangible capital, the more dynamic is the technological environment. Second, another point they raise is that their models show that innovations, if imitated, produce externalities. If that is the case, then education, due to its stimulation of innovation, also yields externalities. These later points highlight a possible source of divergence between the private and social rate of return to education.

3.4 The effect of agricultural education on occupational choice

Elsewhere in the literature, the impact of human capital on the allocation decision for farm households between agricultural and non-agricultural activity is explored (e.g. Yang and An**,** 2002). The later can take the form of either part-time farming or permanently exiting the agricultural sector. The argument here is that general education helps farmers respond to changing conditions by reallocating their human and physical resource. Analysis of any such occupational effect from education is not considered as part of the present study.

Hennessy and Rehman report (2007) that for Ireland, in terms of occupation choice, farm heirs with a third level education *other than agricultural education*, are more likely to: enter farming part-time rather than full-time; enter a non-farming occupation and to be undecided about their occupation choice.

4.0 Context

4.1 Formal Agricultural Education

There are four main types of formal agricultural education courses available in Ireland.

1) Higher level courses (see Appendix) which are conducted jointly between Teagasc and the Institutes of Technology are accredited by the Higher Education and Training Awards Council (HETAC) and are applied for through the Central Applications Office (CAO) system. In most situations holders of Higher Certificates are eligible to progress up the National Framework of Qualifications ladder.

2) Further education courses (see Appendix) are accredited by the Further Education and Training Awards Council (FETAC) and application is usually directly to Teagasc colleges or Regional Education Centres (REC). These courses are suitable for people who wish to make a career in agriculture, horticulture, the equine sector or forestry but who do not wish to complete a higher level course. There is no minimum educational entry requirement but those who have completed the Leaving Certificate are likely to benefit most.

3) University level agricultural training is delivered in some universities. Three examples include the Bachelor of Science in Horticulture delivered by Dublin City University and the College of Amenity Horticulture, National Botanic Gardens; the Bachelor of Agricultural Science (Hons) in Dairy Business delivered in UCD and Teagasc Moorepark and Kildalton and the broader Bachelor of Agricultural Science in UCD.

4) There are a variety of adult and continuing education (short courses) delivered in Teagasc education offices.

Four slightly different categories of formal agricultural education are focused on in this study; agricultural college, agricultural certificate, agricultural training at university level and short courses. The first two categories do not map directly onto the four types of education listed above, although the final two categories do. Therefore, the components of the first two categories are outlined in detail below:

Agricultural College

This category includes the range of higher level education programmes (and all further education programmes not included in the 'Agricultural Certificate' category below) in agriculture, horticulture, agri-business, agricultural mechanisation and equine studies which are provided jointly between Teagasc colleges and some Institutes of Technology (Cork Institute of Technology; Dundalk Institute of Technology; Galway-Mayo Institute of Technology; Waterford Institute of Technology; Limerick Institute of Technology; Athlone Institute of Technology and Tralee Institute of Technology). Teagasc has a network of 4 colleges[1], an e college and there are also 3 private colleges[2].

Agricultural Certificate

Of particular interest for this study is the Certificate in Agriculture (FETAC Level 5) and Specific Purpose Certificate in Farm Administration[3] (Teagasc Green Cert, FETAC Level 6) which are delivered in both Agricultural Colleges (Teagasc and private) and, *uniquely among the Further Education courses, at Teagasc Regional Education Centres (REC)*[4]. Within the colleges these courses of study are full time. If delivered in a Teagasc REC they are part time. As a general rule, those attending at an REC are over 23 years of age, while those pursuing a Certificate at an agricultural college are under 23 years of age. The agricultural certificate is considered the key foundation qualification for farmers, not least due to its practical orientation which includes a 12 week farm placement).

4.2 Policy

There are several existing or recently concluded policy instruments geared towards incentivising the restructuring and modernisation of the agricultural sector, which require a minimum level of formal agricultural education as part of their mandatory qualifying criteria. In the section below, the formal education qualifications outlined are the minimum needed to satisfy the education requirements of the various policy instruments. Of particular interest is the first policy instrument – Stamp Duty Exemption – which is used as an instrumental variable in later analysis.

[1]Clonakilty Agricultural College; Kildalton Agricultural and Horticultural College; Ballyhaise Agricultural College; College of Amenity Horticulture; Teagasc.
[2]Gurteen Agricultural College; Mountbellew Agricultural College; Pallaskenry Agricultural College.
[3]This course is suitable for people who wish to meet the minimum educational qualification requirement for Stamp Duty Exemption on the transfer of land.
[4]Teagasc has twelve Regional Education and Training Centres, one in each of its 12 Regional Units.

1) Stamp Duty Exemption
The Finance Act of 1994 introduced stamp duty relief on the transfer of land to young trained farmers. Although initially relief was implemented at 66%, there is a 100% exemption until December 31, 2015. The farmer has to be less than 35 years of age on the date of transfer and must be the holder of an appropriate FETAC certificate in respect of an approved training course (the minimum is FETAC Level 6 Specific Purpose Certificate in Farm Administration or equivalent).

2) Stock Relief
There is a 100% stock relief measure available to young, trained farmers. This relief enables them to offset any increase in the value of stock against their tax liability. This measure effectively aids young farmers to build up stock numbers during their first four years in farming. A FETAC Level 6 Specific Purpose Certificate in Farm Administration or equivalent is required. This relief is secured until December 31, 2015.

2) New Entrant in a Milk Production Partnership
A key criterion is that the new entrant is under 35 years of age at the date of application and has at least a FETAC Level 6 Advanced Certificate in Agriculture or equivalent qualification. If over 35 years of age at date of application, three years farming experience plus 180 hours Teagasc Approved Training Programme is the minimum formal agricultural education requirement.

4) Allocation of Milk Quota to New Entrants
As part of the CAP 'Health Check' agreement in November 2008, EU Member States were able to increase milk quotas annually by 1 per cent over the period 2009 to 2013. In Ireland, the Minister for Agriculture, Food and the Marine allocated one quarter (0.25%) of this increase to New Entrants to Dairying. Included in the qualifying criteria was if the applicant was under 35 years of age at date of application, they should have a FETAC Level 6 Advanced Certificate in Agriculture or equivalent qualification. If over 35 years of age at date of application, the applicant should have three years farming experience plus 180 hours Teagasc Approved Training Programme[6]. This initiative ended in 2013.

4) Other Schemes/Initiatives
Other schemes which also had a formal agricultural education requirement such as Installation Aid, the Early Retirement Scheme and the Single Payment Scheme – National Reserve for New Entrants, are suspended.

4.3 Data

The main data source used in this study is the Teagasc National Farm Survey (NFS) for the years 2001-2011. The NFS surveys a sample of approximately 1,100 farms each year[7]. The NFS is collected as part of the Farm Accountancy Data Network of the European Union. It determines the financial situation on Irish farms by measuring the level of gross output, costs, income, investment and indebtedness across the spectrum of farming systems and sizes and provides data on Irish farm income to the EU Commission in Brussels and a database for economic and rural development research and policy analysis (Connolly et al. 2010).

In the NFS, the principal measure of the income arising from the year's farming activities is Family Farm Income per farm (FFI). FFI represents the financial reward to all members of the family, who work on the farm, for their labour, management and investment. The FFI is calculated by deducting all farm costs (direct and overhead) from the value of farm gross output and adding farm subsidies. It does not include income from non-farming sources and thus may not be equated to household income. The market gross margin relates to net income from the market defined as market gross output minus direct costs. It excludes overheads and subsidies (which are now decoupled from production). This variable is most closely aligned to the substitution effect associated with participating in education and as such should be used in calculating private returns to education.

Most farms in Ireland contain multiple enterprises (beef cattle, sheep, dairy cows, cereals etc.) and so the NFS classifies a farm by the dominant enterprise. The dominant enterprise is defined as the system with the highest share of gross margin. There are substantial variations in margins across enterprises. Dairy farms have the highest family farm incomes per farm, at about twice that of the next highest system. This difference is not accounted for by farm size, but rather by the difference in profitability. High farm incomes for dairy farm systems result from the relatively higher price for the outputs of dairy enterprises on these farms. The cattle sectors, which account for the largest proportion of farms, on the other hand face significant pressures as market farm income (family farm income less subsidies) is negative. These numbers are consistent with historical trends (Connolly et al., 2010).

[6]FETAC certificates (for the 100 hours and 80 hours courses) may be required.
[7]Very small farms, and pig farms are excluded.

4.4 The Methodological Challenge

This study sought to provide evidence on the relationship between formal agricultural education and farm level outcomes. From a statistical perspective, establishing the impact of education on personal economic outcomes is beset by the well-recognised problem of endogeneity (Dickson and Harmon, 2011): a correlation between the regressor(s) and the error term. A critical assumption of the classic linear regression model is that the expected value of the error term, given the value of the regressors, is zero. In other words, the unobserved factors represented by the error term are not systematically related to the regressors or that the regressors are truly exogenous. If this condition holds, then the estimators are considered best linear and unbiased. However, if this condition fails and there is correlation between the error term and one or more regressors, then the estimators might be biased and also inconsistent. The main reasons for correlation between the error term and a regressor are 1) measurement error in the regressors, 2) omitted variable bias or 3) simultaneous equation bias.

What this means for this study is that when looking at the relationship between farm level returns and formal agricultural education we need to address this potential endogeneity problem. To take just one possibility, ideally a farmer's innate ability should be taken into account when looking at farm level returns otherwise the contribution of education to farm level outcomes may be inflated. However, as we do not have measures of innate ability the analysis will suffer from omitted variable bias. Therefore, in a regression of family farm income on education the variable education is likely to be correlated with the regression error term, for that error term may include some measure of farmer ability. In this case, the education variable is an *endogenous regressor* or more formally *a stochastic regressor*. This renders OLS regression results suspect as the estimators are biased as well as inconsistent.

4.5 The Methodological Solution

The challenge is to find a 'substitute' or 'proxy' variable for the suspected endogenous regressors so that the proxy variables produce consistent estimators of the true regression coefficients. If that can be done successfully, such variables are called *instrumental variables* or *instruments*. In choosing instruments, they have to be:

1) Relevant, that is the instrument must be correlated positively or negatively with the stochastic variable for which it acts as an instrument.

2) Exogenous, that is it must not be correlated with the error term.

3) Not a regressor in its own right: that is it does not belong in the original model.

When using instrumental variables, it is not merely the case that X (the original regressor) is replaced with Z (the instrumental variable) and that Y is regressed on Z. Instead it is equivalent to a two stage estimation procedure:

First use OLS to regress X on the instrumental variable Z:

$$\hat{X} = \hat{c} + \hat{d}Z$$

In the second stage, Y is regressed on the predicted from the first equation to get:

$$\hat{Y} = a^* + b^* \hat{X}$$

is known as the instrumental variable. Thus IV estimation is equivalent not to regressing Y on the instrument Z, but on the instrumental variable

4.6 Instrumental Variables

Two main instrumental variables were chosen for inclusion in this analysis.

1) Distance from an agricultural college.
2) Policy change: The year (1994) in which the Stamp Duty Exemption Scheme (targeted at young, trained farmers) was introduced.

Similar instruments are used in other analysis. For example, Card (1995) uses distance to college as an instrument for schooling bases on the observed higher education levels of men who were raised near a four-year college. In examples of the use of policy changes as instruments, Harmon and Walker (1995, 1999, 2000) use changes in the compulsory school leaving age and Callan and Harmon (1999) use the introduction of free schooling.

Taking this into account, the remainder of the study seeks to do three main things after presenting the IRR analysis:

1) Examine the factors that influence the participation of farmers in formal agricultural education (Section 7). Included in this analysis is an assessment of whether the chosen instrumental variables are important for farmer's education participation decisions.

2) Using the instrumental variable approach, identify the impact of formal agricultural education on family farm income (Section 8)

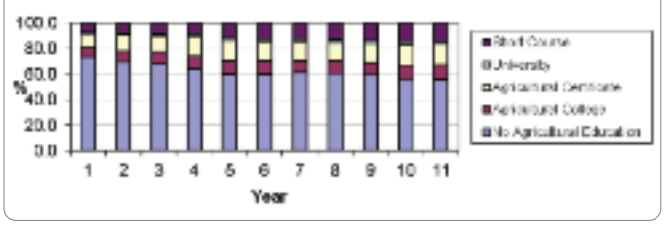
3) Examine the relationship between formal agricultural education and yield and intensity of production at farm level (Section 9).

Before turning to the results of the more formal analysis, the next section provides a descriptive overview of some aspects of the relationships between formal agricultural education and the farming population.

5.0 Overview of Formal Agricultural Education at Farm Level

Figure 5.1 shows that over the period 2001 to 2011, the overall proportion of the farming population having some formal agricultural education increased from 24% of the total to 44%, an increase of 83%. In addition, the proportion of famers with each of the 4 types of formal agricultural education focused on in this report increased. There are, however, differences for the various types of formal agricultural education. While the proportion of famers having either an agriculture certificate, going to agricultural college or attending short courses increased by 57%, 81% and 81% respectively over the decade, the proportion associated with agricultural university training increased by 35%[8].

Figure 5.1: Proportion of the farming population with different agricultural education levels (for those with data), 2000-2011

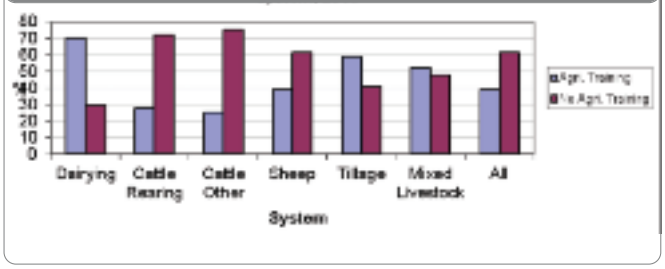


Source: Teagasc NFS

5.1 Agricultural Education by Farming System

Figure 5.2 shows the proportion of farmers with agricultural education by system. It is clear that in 2010 for dairy (70%), tillage (59%) and mixed livestock (52%) systems, the proportion of farmers with agricultural training is above the average (39%). In contrast, for the cattle rearing (28%) and cattle other systems (25%) the proportion of farmers with an agricultural education is below the average.

Figure 5.2: Proportion of farmers with agricultural training by system, 2010

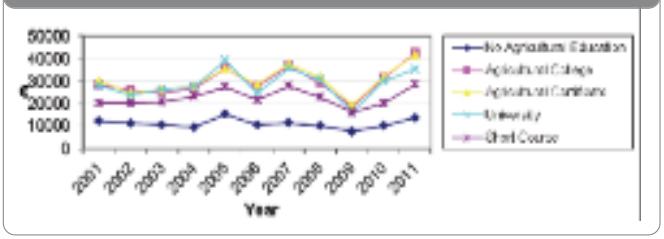


Source: Teagasc NFS

5.2 Farm Income and Agricultural Education Level

Figure 5.3 outlines average family farm income by type of formal agricultural education. Consistently over the period, family farm income is higher where the farmer has undertaken any type of formal agricultural education compared to not having undertaken any. Family farm income is highest where the farmer has either gone to agricultural college or has an agricultural certificate and there is relatively little difference in average family farm income between those households with these two types of education. Looking over the period 2001 to 2011, while the family farm income of those households with no agricultural education increased by 13.6%, those households with agricultural college, agricultural certificate, university and short courses increased by 51%, 39%, 27% and 41% respectively.

Figure 5.3: Average family income by agricultural education level



Source: Teagasc NFS

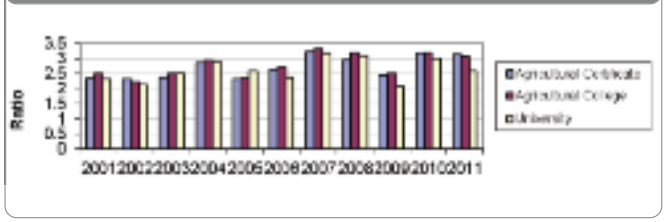
Figure 5.4 depicts relative income measures and four things stand out

- First, it clarifies that family farm income for those farmers who have an agricultural college, certificate or university qualification is consistently between 2 and 3 times higher than those with no formal agricultural education qualification.
- Second, over the period 2001 to 2011 the ratio of income from undertaking an agricultural college or undertaking a certificate compared to no education increased more than the relative benefit in income from undertaking university study compared to no formal agricultural education.
- Third, at the end of the period, the ratio of family farm income for agricultural college and agricultural certificate holders compared to those farmers with no formal agricultural education was higher than that for holders of university qualifications.

[8]All changes over time in this section are derived by comparing the average of the two years at the beginning and end of the period 2001 to 2011.

Fourth, in 2011, the family farm income of those who had either an agricultural college or agricultural certificate was similarly greater than those who had no formal agricultural education.

Figure 5.4: Ratio of family farm income of those with agricultural college, certificate or university courses compared to those with no formal agricultural education

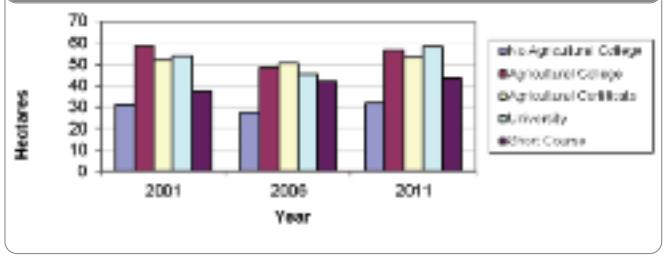


Source: Teagasc NFS

5.3 Farm Size and Agricultural Education

Figure 5.5 examines the relationship between farm size and agricultural education. It is clear that those farmers with some formal agricultural education have larger farms. Over the period, the average farm size of those without agricultural education has declined by 1.6% whereas the size of farm for those with agricultural college, certificate, university qualification or short courses has increased by 0.9%, 2.9%, 2.8% and 7.8% respectively.

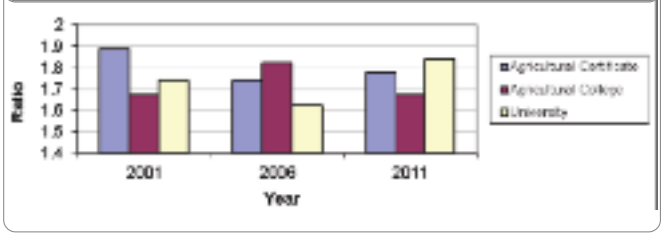
Figure 5.5: Average farm size by type of agricultural education



Source: Teagasc NFS

Figure 5.6 looks at the relative average farm size over the period and shows that for those farmers with agricultural education, their farms are consistently between 1.6 and 1.9 times larger than those farmers without formal agricultural education. In terms of change, the ratio has increased over the period, by 1.6% for those with an agricultural certificate; 5.2% for those with agricultural college training and 5.4% for those with agricultural university training.

Figure 5.6: Ratio of average farm size for those with specific types of agricultural education compared to those with none



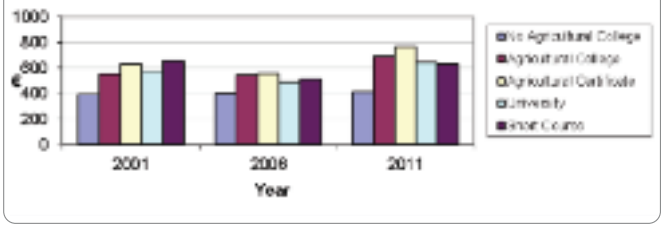
Source: Teagasc NFS

5.4 Farm Income per Hectare and Agricultural Education

Figure 5.7 presents data on average family farm income per hectare. There are three findings of note.

- First, consistently over the period, those farmers with formal agricultural education have higher farm income per hectare.
- Second, at the end of the period, while those farmers with agricultural college, certificate or university education had an income per hectare greater than the average, those with short courses education had an income per hectare slightly below the average.
- Third, while farm income per hectare had fallen over the period for those with no agricultural education and those with short courses by 1.8% and 10% respectively, for those with agricultural college, certificate and university education, it had grown by 14%, 19% and 17% respectively.

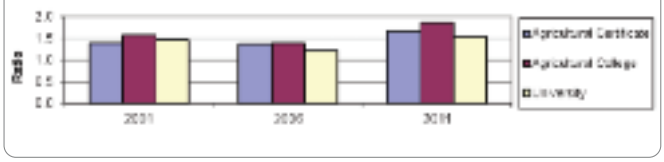
Figure 5.7: Average family farm income per hectare by type of agricultural education



Source: Teagasc NFS

Figure 5.8 shows farm income per hectare for those with agricultural education relative to those without any formal agricultural education. For the three types of formal agricultural education, average family farm income per hectare is consistently between 1.3 and 1.9 times greater than those farmers without any formal agricultural education. Over time that differential has increased significantly with the ratios for agricultural certificate, agricultural college and university education increasing by 15.7%, 21.6% and 21% respectively.

Figure 5.8: Ratio of average family farm income per hectare of those with various types of agricultural education compared to those with no formal agricultural education

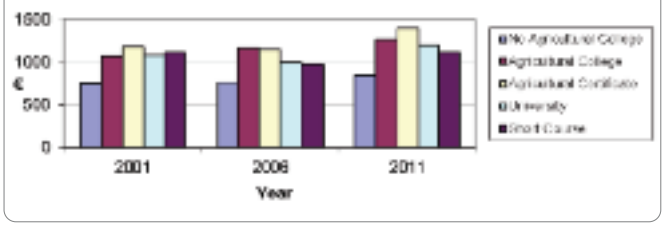


Source: Teagasc NFS

5.5 Gross Margin and Agricultural Education

Figure 5.9 outlines data on average gross margin per hectare. Those farmers with agricultural education have a higher average gross margin per hectare than those farmers without formal agricultural education. Farmers with agricultural college, certificate and university education have a higher average gross margin than all farmers whereas those without any formal agricultural education record average gross margins lower than the average for all farmers. For those farmers with short courses education, their average gross margins per hectare are just below the average for all farmers.

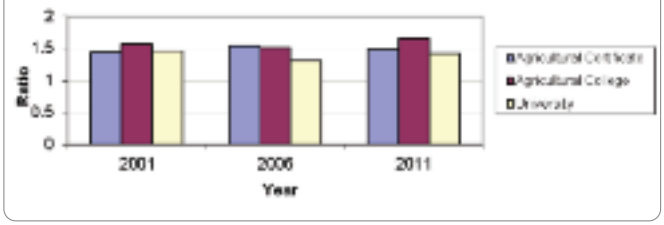
Figure 5.9: Average farm gross margin per hectare by agricultural aducation



Source: Teagasc NFS

Turning to the relativities around average farm gross margin per hectare, Figure 5.10 clarifies the relationship between those farmers with formal agricultural education and those without. Gross margins are consistently between 1.3 and 1.7 higher for farmers with agricultural education than those without. There are differences in the changes in the ratios over the period, however. While the ratio for those with agricultural certificates and agricultural college qualifications increased by 3.25% and 8.9% respectively, those for agricultural university education increased by 4.2%.

Figure 5.10: Ratio of average farm gross margin per hectare for those with agricultural education compared to those without



Source: Teagasc NFS

6.0 The Internal Rate of Return to Investment in Agricultural Education

6.0 The Internal Rate of Return to Investment in Agricultural Education

In evaluating the return on a capital investment the Internal Rate of Return (IRR) is often used to compare alternative investments. Following Becker (1962) who introduced the concept of treating investment in education as a capital investment, IRR is often utilised in studying the return to education by comparing the cost of providing education with the benefit from receiving the education. The IRR to education is the discount rate, r in formula (1) such that discounted benefits of extra education, Benefit(s+σ+ δ) – Benefit(s) are equal to discounted costs of education, Cost(s+ δ), where s is the amount of schooling and δ is an extra amount of education.

$$\sum_{t=1}^{n} (\text{Benefit}(s+\delta) - \text{Benefit}(s))_t \times (1+r)^{-t} = \sum_{t=1}^{n} \text{Cost}(s+\delta)_t \times (1+r)^{-t}$$

The definition of costs and benefits, however, depend upon the perspective of the particular investor. So for example a student or their family will focus on costs and benefits that apply to the student in terms of foregone earnings, course fees and returns in terms of income. This is known as the *private rate of return*. From the perspective of the state, the benefits relate to the impact on output and other income streams relative to the total cost of providing the education. This is known as the *social rate of return*.

In terms of the impact upon total output, the output generated at farm level can be narrowly focused upon to generate a measure of the internal rate of return. However, in producing output, farmers have quite a large local multiplier due to the inputs required for production. The Central Statistics Office (CSO) input-output tables have a multiplier of 1.277. In other words, the agricultural sector generates 27.7 cent of output for every 1 euro of final demand. In addition, the presence of agricultural output also leverages output in the processing sector. The output from the food processing sector is 4.16 times the inputs from the agricultural sector. Combining the supply chain impact, there is a total multiplier of 1.086 relative to the processor value according to the CSO. Thus there is quite a substantial supply chain impact of additional food produced. Without the agricultural output at farm level, these gains would not be realised.

In Table 6.1 the costs and benefit assumptions used in the IRR analysis are reported. The costs borne by the student are the course fees and the earnings foregone. The average fee per student in Kildalton College is used as a measure of fees. Foregone earnings are assumed to be at the minimum wage at 40 hours per week for 52 weeks. In undertaking the analysis, two alternative assumptions are used in relation to foregone earnings.

- First, that the student would have worked full-time
- Second, the student would have worked with a probability of 0.7 as the ILO unemployment rate for 15-19 year old males is currently 30.1% (CSO Quarterly National Household Survey)

In the latter assumption, expected foregone earnings are used in the cost function.

In terms of benefits, it is assumed that the farmer has an influence over the farm at age 30, where the return at farm level is related to the market gross margin. In order to use conservative estimates, it is assumed that there is no return to other non-agricultural economic activities between leaving agricultural college at 19 and taking up farming at age 30. For the same, reason, any additional returns to off-farm employment are ignored. Table 6.1 reports the weighted average premium adjusted for inflation in terms of market gross output and market gross margin for the period 2010-2012. The weight is by the share of farms in different systems participating in agricultural education.

The importance of weighting relates to the selection bias associated with taking the straight average of all farms. For example, while the average premium for the gross margin is €300 per hectare using mean 2010-2012 data, the weighted average is €159. The lower weighted average is used due to the fact that there is selection bias amongst those who participate in agricultural education. For example 60% of Dairy Farmers, who have much higher incomes, participate in formal agricultural education, while 25% of sheep farmers do. Thus part of the reason for the higher margin is this selection effect. Until 2015 when Milk Quota will be abolished, there is limited opportunity to move systems and so sheep farmers could not convert to dairy and get a higher associated premium. Similarly, the average output premium is €510, while the mean weighted average is €409. Again on the basis of generating conservative estimates, the lower amount is utilised. However, it could be argued that the premium could be higher in the future arising from opportunities to convert to dairy farming.

Higher subsidy rates are associated with higher education. This was a function of the coupled payment structures prior to 2005. Since decoupling, payments are a function of land rather than production and from 2015 will converge to close to a per hectare payment. From a conservative perspective therefore, subsidies are ignored in the calculation of returns. Overhead costs are also ignored,

assuming that other investments and land remain constant. The average size of a farm for those who have agricultural education is 56 hectares, which is larger than the average farm. A conservative 1% productivity growth per annum is assumed.

From a social return perspective, the multipliers defined above in relation to farm level multipliers associated with input costs, the impact of additional agricultural output at the supply chain scale and the multiplier associated with this production are used.

In Table 6.2, the resulting IRR on investment to participating in a two year course of agricultural education is reported. The Private rate of return, which is the basis for those contemplating pursuing agricultural education, is 8.8% when full employment is assumed. If the youth unemployment rate is factored in, the private rate of return rises to 10.4%. This is slightly lower than the private rate of return calculated by O'Donoghue (2000) for Upper Secondary Education of 17.0% in Ireland, but substantially higher than that for tertiary education at 5.8%.

The farm based social rate of return is higher at 13.4% when full employment is assumed and 14.8% when a 30% unemployment risk is assumed. The latter are slightly lower than the social rate of return calculated in Ireland for Upper Secondary Education of 15.7%, but higher that that calculated for Tertiary education of 5.7%. By incorporating total impacts on the sector, the social rate of return is the more appropriate measure to be used when undertaking public sector investment decisions. When the wider supply chain impact of improved agricultural productivity is factored in, there is a very high rate of return of 24.5% and 26.3% for full employment and unemployment risk assumptions respectively, reflecting the high national multiplier of agricultural production.

Table 6.1: Costs and Benefits of Agricultural College Education

Costs	**Private**	**Social**
Fees per student	2016	2016
Salary Cost per student		4018
Non Pay Cost per student		3471
Earnings Foregone per student	17992	17992
Benefits		
Market Gross Margin Premium	159	
Market Gross Output Premium		409
Average Farm Size for farmer participating in Agricultural College Education	56ha	56ha
Age Taking over farm	30	30
Processor Output Impact		4.16
Supply Chain Multiplier		1.088

Table 6.2: Internal Rate of Return

	Private	**Social**
At Farm Level		
Full Employment	0.088	0.134
30% Unemployment Risk	0.104	0.148
With Supply Chain Impact		
Full Employment		0.245
30% Unemployment Risk		0.263

7.0 Participation in Formal Agricultural Education

It is important to get an understanding of the key factors that impact farmers' participation in formal agricultural education. The appropriate statistical method to analyse such participation decisions given the type of data used, is logistic regression. The effects of a variety of potential farmer, farm, location and policy categorical and continuous explanatory variables were hypothesised. Of particular interest is to explore the impact on farmer participation in formal agricultural education of the three potential instrumental variables to be used in later analysis 1) farmer's geographic distance from an agricultural college 2) whether a farmer was over 35 years of age in 1994 when the Stamp Duty Exemption for qualified farmers was introduced and 3) a variable capturing the interaction between distance and farmer's age in 1994. To be able to be used in later analysis, these three variables need to be significant and of the expected sign in the logistic regression.

7.1 Participation in Agricultural College

Two participation models were developed; one for the decision to participate in agricultural college, the second the decision to undertake an agricultural certificate. The results of the participation decision model for Agricultural College are presented in Table 7.1.

The table includes the estimated coefficients, standard error, z-statistic and a goodness of fit measure for the model. The likelihood ratio statistic suggests that the model is significant ($p<0.01$). Variables with a positive coefficient increase the probability of participation while those with a negative coefficient decrease the probability. The first three variables in Table 7.1 are the potential instrumental variables for later analysis. These three variables have the expected signs and are significant.

- The first variable, Age over 35 years in 1994 is a proxy for the group of farmers that are differentially affected by agricultural restructuring policy instruments such

Table 7.1: Participation in Agricultural College

Variable	Coefficient	SE	Z-Statistic
Constant	-1.965346		
Over 35 years of age in 1994	-.5325663***	.0728672	-7.31
Distance to College	-.000092**	.0000196	-4.68
Interaction between age and distance	.0000685***	.0000236	2.90
Land Value	.341001***	.0576493	5.92
Total Livestock Units	.2352052***	.0636962	3.69
Forage Area	.4306436***	.1085692	3.97
Age	-.1339177**	.0482952	-2.77
Size (UAA)	.5376827***	.0472612	11.38
Forestry	.4378017***	.1101451	3.97
Teagasc client	-.1367228**	.0575131	-2.38
Region 2	.5514435***	.1274181	4.33
Region 3	1.042567***	.2361433	4.41
Region 4	.9070882***	.1315799	6.89
Region 5	.823867***	.131292	6.28
Region 6	.8147598***	.1327317	6.14
Region 7	1.003298***	.1238924	8.10
Region 8	.4363832**	.1268071	3.44
Soil type 1	-2.831024**	1.168244	-2.42
Soil type 2	-2.579979**	1.171089	-2.20
N=14216	Likelihood Ratio Statistic $\chi^2_{35} = 795.09$***		
**p<0.05, ***p<0.001			

Note: Region 1 - Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan: Region 2 – Dublin: Region 3 - Kildare, Meath, Wicklow: Region 4 - Laois, Longford, Offaly, Westmeath: Region 5 - Clare, Limerick, Tipp N.R: Region 6 - Carlow, Kilkenny, Wexford, Tipp S.R., Waterford; Region 7 - Cork, Kerry; Region 8 - Galway, Mayo, Roscommon

as Stamp Duty Exemption for qualified farmers under 35 years of age, introduced in 1994, over and above the age effect. The effect of a farmer being older than 35 in 1994 is significant and negative. In other words, if a farmer was 35 years of age before 1994, (s)he is less likely to go to agricultural college.

- The negative and significant effect of the variable distance to college is straightforward: the greater the distance a farmer is from an agricultural college the less likely the farmer is to go to college.

- The variable interaction between age and distance is positive and significant: therefore, the negative distance effect is exacerbated by age.

For the other variables, higher land values, livestock unit, forage area, size of farm all positively impact participation in agricultural college. The positive and significant effect of the variables Region 2 to Region 8 in the table means that if a farmer is located anywhere in the country other than region 1 (Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan) they are more likely to attend agricultural college.

Unsurprisingly, there is a negative and significant effect of age on participation in agricultural college. The negative and significant coefficient on the Teagasc client variable is due to multi-collinearity. Inspection of the underlying data reveals that the correlation is actually weakly positive, but turns signs as Teagasc membership is also related to characteristics that are related to higher productivity that are also related to agricultural education participation. The negative and significant effect of soil types 1 and 2, the good and medium quality soils, suggests that notwithstanding regional variations in education participation, farmers that have inherently more productive farms might decide not to pursue a formal agricultural education

7.2 Participation in an Agricultural Certificate

The results of the participation decision model for agricultural certificates are presented in Table 7.2. Again the table includes the estimated coefficients, standard error, z-statistic and a goodness of fit measure for the model. The likelihood ratio statistic suggests that the model is significant ($p<0.01$). As with Table 7.1, variables with a positive coefficient increase the probability of participation while those with a negative coefficient decrease the probability.

Table 7.2: Participation in Agricultural Certificate Course

Variable	Coefficient	SE	Z-Statistic
Constant	-1.349851		
Over 35 years of age in 1994	-1.416094***	.0629258	-22.50
Distance to College	.0000343**	.0000119	2.87
Interaction between age and distance	-.0000257**	.0000164	-1.56
Forage Area	1.179365***	.0938905	12.56
Size (UAA)	.4364529***	.0419937	10.39
Teagasc client	.3951407***	.0512173	7.71
REPS	.104787**	.051613	2.03
Region 2	.6247665***	.1130821	5.52
Region 3	.6539674**	.239578	2.73
Region 4	.6974364***	.1222952	5.70
Region 5	1.354913***	.117159	11.56
Region 6	.7898608***	.120305	6.57
Region 7	.9728075***	.1124013	8.65
Region 8	1.490451***	.10847	13.74
Soil type 1	-3.972403***	.951246	-4.18
Soil type 2	-4.812035***	.9555681	-5.04
N=14216	Likelihood Ratio Statistic $\chi 235 = 2677.90$***		

**p<0.05, ***p<0.001

Note: Region 1 - Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan: Region 2 – Dublin: Region 3 - Kildare, Meath, Wicklow: Region 4 - Laois, Longford, Offaly, Westmeath: Region 5 - Clare, Limerick, Tipp N.R: Region 6 - Carlow, Kilkenny, Wexford, Tipp S.R., Waterford; Region 7 - Cork, Kerry; Region 8 - Galway, Mayo, Roscommon.

The first three variables are all significant.

- Similar to the first model, the effect of being older than 35 in 1994 is negative and significant: if a farmer was 35 years of age before 1994, (s)he is less likely to undertake an agricultural certificate.

- However, in this second model, there is a significant positive effect of distance from an agricultural college and participation on an agricultural certificate course. This could be interpreted as follows: farmers who are further away from an agricultural college substitute an agricultural certificate delivered locally in a Teagasc Regional Education Centre as their preferred formal agriculture education qualification.

- The effect of the variable 'interaction between age and distance' is negative and significant, and therefore, opposite in effect compared to the first model. The interpretation is that the positive distance effect (i.e. the incentive for substitution for an agricultural certificate the further a farmer is from an agricultural college) is reduced by the age of the farmer.

In relation to the other variables, in contrast to the first model, higher land values, more livestock units, age and forestry on the farm are not significant variables explaining participation in an agricultural certificate course.

Being a Teagasc client and participating in a REPS scheme has a positive and significant effect on undertaking an agricultural certificate. Similar to the previous analysis on participation in agricultural college, the positive and significant effect of the variables Region 2 to Region 8 in the table means that if a farmer is located anywhere in the country other than region 1 (Louth, Leitrim, Sligo, Cavan, Donegal, Monaghan) they are more likely to participate in an agricultural certificate. The negative and significant effect of soil types 1 and 2, the good and medium quality soils, indicates that notwithstanding regional variations on education participation, farmers that have inherently more productive farms might decide not to pursue a formal agricultural education.

8.0 The Returns to Farm Income from Formal Agricultural Education

The participation analysis in the previous chapter confirms that the chosen instrumental variables have potential; they are significant and have the hypothesised signs. Therefore, in this section they are included in an analysis of the impact of formal agricultural education on family farm income.

Three sets of results are reported here. The first focuses on agricultural certificate, the second agricultural college and the third on agricultural education in aggregate. The analysis follows the 2 step procedure outlined in Section 4.

8.1 Returns to Agricultural Certificate.

Focusing first on returns to agricultural certificate education, a random effects panel regression with Family Farm Income per hectare as the dependant variable was used. This regression contained a variety of potential farmer, farm and geographic explanatory variables including four types of agricultural education. For clarity, only the education related variables are included in Table 8.1.

The results of the first stage of the IV process where the potentially endogenous variable agricultural certificate is regressed on the instrumental variables, is outlined in Table 8.2. The coefficients are of the expected sign and are significant.

In the second stage, the dependant variable Family Farm Income per hectare is regressed on the instrumental variables generated from the first stage. The results, shown in Table 8.3, are significant and of the hypothesized sign.

In Table 8.4, the coefficients from the Instrument Variable approach and the Regression 1 are compared. The IV coefficients for the education variables are higher than the original regression. This relationship between IV and OLS coefficients is also found in the international literature.

Table 8.1: Family Farm Income per hectare and agricultural education variables: Regression 1

FFI/ha	Coefficient	SE	p	95% CI	
Ag Cert	0.114571	0.0369888	0.002	0.0420742	0.1870678
Ag College	0.1727391	0.0434976	0.000	0.0874854	0.2579928
University	0.1357661	0.0864209	0.116	-0.0336157	0.3051479
Short Courses	0.1586871	0.0411635	0.000	0.0780081	0.2393661

Table 8.2: First Stage of the IV process: agricultural certificate

Ag Cert	Coefficient	SE	p	95% CI	
Over 35 yrs in 1994	-0.1690888	0.0074318	0.000	-0.1836549	-0.1545227
Interaction between age and distance	-6.36E-06	1.90E-06	0.001	-0.0000101	-2.64E-06
Distance to college	5.63E-06	1.74E-06	0.001	2.22E-06	9.03E-06

Table 8.3: Instrumental Variable results

FFI/ha	Coefficient	SE	p	95% CI	
Ag Cert	0.4135787	0.144565	0.004	0.1302361	0.6969212
Ag College	0.2629433	0.060484	0.000	0.1443961	0.3814905
University	0.2390942	0.096135	0.013	0.0506741	0.4275143
Short Courses	0.2381195	0.054361	0.000	0.1315731	0.3446659

Table 8.4: Comparison between the IV and Regression 1 Results

		IV		RE1	
Ag Cert		0.4135787		0.114571	
Ag College		0.2629433		0.1727391	
University		0.2390942		0.1357661	
Short Courses		0.2381195		0.1586871	

8.2 Returns to Agricultural College

Focusing on returns to agricultural college education, the first stage in this analysis was exactly the same as for the agricultural certificate. A random effects panel regression with Family Farm Income per hectare as the dependant variable was used. The results are the same as found previously.

The results of the first stage of the IV process where the potentially endogenous variable agricultural college is regressed on the instrumental variables, is outlined in Table 8.5. The coefficients are of the expected sign and are significant.

In the second stage, the dependant variable Family Farm Income per hectare is regressed on the instrumental variables generated from the first stage. The results, shown in Table 8.6, are significant and of the hypothesized sign.

In Table 8.7, the coefficients from the Instrument Variable approach and Regression 1 are compared. The IV coefficients for the education variables are higher than the original regression, again confirming the relationship between IV and OLS coefficients that is found in the international literature.

8.3 Returns to Aggregate Agricultural Education

A third analysis explored an aggregate variable named agricultural training, which included agricultural college, agricultural certificate and agricultural university education. The results of the first stage of the IV process where the potentially endogenous variable agricultural training is regressed on the instrumental variables, is outlined in Table 8.8. The coefficients are of the expected sign, but for distance to college and the interaction term, they are not significant.

Table 8.5: First Stage of the IV process: agricultural college

Ag College	Coefficient	SE	p	95% CI	
Over 35 yrs in 1994	-0.0845869	0.0064178	0.000	-0.0971654	-0.0720083
Interaction between age and distance	3.80E-06	1.62E-06	0.019	6.28E-07	6.97E-06
Distance to college	-4.98E-06	1.50E-06	0.001	-7.91E-06	-2.04E-06

Table 8.6: Instrumental Variable results

FFI/ha	Coefficient	SE	p	95% CI	
Ag College	0.8783213	0.352503	0.013	0.1874286	1.569214
Ag Cert	0.273222	0.087043	0.002	0.1026218	0.4438221
University	0.3295626	0.129576	0.011	0.0755981	0.583527
Short Courses	0.2847411	0.074949	0.000	0.1378445	0.4316377

Table 8.7: Comparison between the IV and Regression 1 Results

		IV		RE1	
Ag College		0.8783213		0.1727391	
Ag Cert		0.273222		0.114571	
University		0.3295626		0.1357661	
Short Courses		0.2847411		0.1586871	

In the second stage, the dependant variable Family Farm Income per hectare is regressed on the instrumental variables generated from the first stage. The results, shown in Table 8.9, are significant and of the hypothesized sign.

In Table 8.10, the coefficients from the Instrumental Variable approach and the relevant OLS regression (named Regression 3 and shown in table below) are compared. The IV coefficients for the education variables are higher than the OLS regression, a result which is again in line with findings from the international literature.

The IV approach in this chapter confirms that when endogeneity is accounted for in the analysis of the impact of formal agricultural education on family farm income, it reinforces the positive effect displayed in the original regression formulations. In each case, either looking at agricultural certificates or agricultural college separately, or an aggregated measure of formal agricultural education, the IV generated education coefficients were higher. This general relationship between IV and OLS estimates in education studies is confirmed by Harmon et al. (2003) in a meta-analysis of such studies.

Table 8.8: First Stage of the IV process: agricultural training

Ag Training	Coefficient	SE	p	95% CI	
Over 35 yrs in 1994	-0.2259583	0.0091423	0.000	-0.2438769	-0.2080398
Interaction between age and distance 5.15E-06		5.64E-07	2.34E-06	0.809	-4.02E-06
Distance to college	-4.12E-07	2.15E-06	0.848	-4.62E-06	3.80E-06

Table 8.9: Instrumental Variable results

FFI/ha	Coefficient	SE	p	95% CI	
Ag Training	0.3380392	0.117689	0.004	0.1073731	0.5687054

Table 8.10: Comparison between the IV and Regression 3 Results

		IV		RE3	
Ag Training		0.3380392		0.1039771	

9.0 The Returns to Yield and Intensity from Formal Agricultural Education

Table 9.1 presents selected results from system level production function analyses. This analysis tries to get a deeper understanding of the particular pathways through which farm income is impacted by formal agricultural education. Two dependant variables, yield and intensity, were used for each of the four farming systems – Dairy, Cattle, Sheep and Cereals. For livestock sectors, yield equates to Gross Output per LU and intensity is reflected by LU per hectare. In the cereals sector, yield is synonymous with Gross Output per hectare and intensity is reflected by Cost per hectare. For clarity, only the agricultural education explanatory variables are presented in Table 9.1. Once again, formal agricultural education is disaggregated into four: has studied at agricultural college, has agricultural certificate, has university agricultural education and agricultural short courses.

9.1 Dairy sector returns

For the dairy sector, both yields and intensity of output are affected positively and significantly by attending agricultural college and by achieving an agricultural certificate. In addition, undertaking an agricultural course at university also positively and significantly affect yields. Although the positive effect on yields is strongest from having studied agriculture at university followed by agricultural college then agriculture certificate, by contrast, for intensity, the impact of having studied at agricultural college is stronger than that from an agricultural certificate.

9.2 Cattle sector returns

For the cattle sector, both yields and intensity of output are affected positively and significantly by attending agricultural college, achieving an agricultural certificate and attending short courses. In addition, undertaking an agricultural course at university also positively and significantly affect yields. Although the positive effect on yields is strongest from having studied at university followed by agricultural college, agricultural certificate and short courses, by contrast, the effect on intensity is strongest for agricultural college, followed by agricultural certificate and short courses. However, the differential impact between agricultural college and agricultural certificate is negligible.

9.3 Sheep sector returns

For the sheep sector, intensity is significantly and positively affected by attending agricultural college, achieving an agricultural certificate and short courses. There is a negative sign on the short course variable in terms of productivity but it is not significant.

9.4 Cereals sector returns

For the cereals sector, the analysis did not reveal any significant relationships between any of the education variables and yield. However, all the education variables except for university course had the expected positive signs in relation to cereal yields. Unfortunately, no analysis could be carried out in relation to the intensity of cereal output. The poor results on cereals yield analysis and the inability to generate results for intensity is primarily due to the difficulty with modelling the cereals sector due to small respondent numbers in the NFS.

In summary, the generally positive and significant relationships between formal agricultural education and farm level yield and intensity identified in Table 9.1 are supported by the international literature.

Table 9.1: System Yield and Intensity and Relationship with Formal Agricultural Education

	Dairy		Cattle		Sheep		Cereals	
	Yield	*Intensity*	*Yield*	*Intensity*	*Yield*	*Intensity*	*Yield*	*Intensity*
Has Studied in Ag College								
Coefficient	**0.0682998**	**0.0831856**	**0.1952131**	**0.1285074**	0.0744458	**0.1367661**	0.0495765	----------
SE	**0.0230465**	**0.0247709**	**0.034603**	**0.0229723**	0.0698255	**0.0453578**	0.0704711	----------
p-value	**	***	***	***		**		----------
Has Studied Ag Cert								
Coefficient	**0.0419809**	**0.0621489**	**0.1695009**	**0.1163834**	0.0565106	**0.1165007**	0.037928	----------
SE	**0.0183921**	**0.0198667**	**0.0287021**	**0.019021**	0.0577833	**0.0364546**	0.0611036	----------
p-value	**	**	***	***		***		----------
Has Studied Agriculture at University								
Coefficient	**0.0802804**	0.0440478	**0.2950676**	0.0755988	0.1927704	**0.0988242**	-0.1278294	----------
SE	**0.0410057**	0.0430061	**0.0671137**	0.0428301	0.1444877	**0.0887785**	0.1573797	----------
p-value	**		***					----------
Has studied Short Courses								
Coefficient	0.0375948	0.0179913	**0.1062233**	**0.0558458**	-0.0102384	**0.0913406**	0.0647982	----------
SE	0.0240609	0.0260974	**0.0326877**	**0.0213438**	0.0629022	**0.0404923**	0.0729657	----------
p-value			***	**		**		----------

**p<0.05, ***p<0.001

Note: For Dairy, Cattle and Sheep, Yield = Gross Output per LU: Intensity = LU per ha.
For Cereal: Yield = GO per ha: Intensity = Cost per h

10.0 Conclusion

In conclusion, this study focused on identifying the economic returns to formal agricultural education for Irish farmers. The analysis confirms a positive and significant return both in terms of the internal rate of return from a human capital perspective but also clarifies the internal returns from agricultural education to farm level yields, intensity and income when viewed from a production function perspective.

The analysis confirms patterns in the international literature on returns to education.

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Appendix: Formal Agricultural Education

Higher Level Education Programmes

As of 2014, there are 11 higher level programmes delivered in collaboration between Teagasc and various Institutes of Technology. For more information see: www.teagasc.ie/training/courses.asp

- Higher Certificate in Agriculture - HETAC Level 6
- Higher Certificate in Technology in Agricultural Mechanisation - HETAC Level 6
- Bachelor of Business in Rural Enterprise and Agribusiness - HETAC Level 7
- Bachelor of Science in Agriculture and Environmental Management - HETAC Level 7
- Bachelor of Science in Agricultural Science - HETAC Level 7
- Bachelor of Agricultural Science (Hons) in Dairy Business - HETAC Level 8
- Teagasc Professional Diploma in Dairy Farm Management - HETAC Level 7
- Bachelor of Science in Horticulture - HETAC Level 7
- Bachelor of Science in Horticulture - HETAC Level 8
- Higher Certificate in Business in Equine Studies - HETAC Level 6

Further Education Programmes

All of Teagasc's further education courses are accredited by FETAC. These courses are suitable for people who wish to make a career in agriculture, horticulture, horses or forestry but who do not wish to complete a higher level course. There is no minimum educational entry requirement but those who have completed the Leaving Certificate are likely to benefit most. Participants who achieve the necessary results may transfer to higher level courses and progress up the National Framework of Qualifications ladder.

For more information see:

www.teagasc.ie/training/courses.asp

- Certificate in Agriculture - FETAC Level 5
- Specific Purpose Certificate in Farm Administration (Teagasc Green Cert) - FETAC Level 6
- Advanced Certificate in Agriculture - Dairy Herd Management - FETAC Level 6
- Advanced Certificate in Agriculture - Drystock • Management - FETAC Level 6
- Advanced Certificate in Agriculture - Agricultural Mechanisation - FETAC Level 6
- Advanced Certificate in Agriculture - Crop and Machinery Management - FETAC Level 6
- Certificate in Horticulture - FETAC Level 5
- Advanced Certificate in Horticulture - FETAC Level 6
- Certificate in Horsemanship (Equitation or Stud Management) - FETAC Level 5
- Advanced Certificate in Horsemanship - FETAC Level 6
- Advanced Certificate in Equine Breeding (Stud Management) - FETAC Level 6
- Certificate in Forestry - FETAC Level 5
- Advanced Certificate in Forestry - FETAC Level 6

Adult and Continuing Education

Lifelong learning and continuing education are now a feature of all professions and walks of life. To meet this demand Teagasc offers a wide range of courses for adults and agri-food sector employees. The courses, which are delivered at local Teagasc offices, are delivered in modules of 12.5 or 25 hours duration. Some of the courses are accredited by FETAC and participants have the option of accumulating modules and progression to FETAC major awards. The courses are provided subject to demand and staff resources being available. The list below is not exhaustive. For more information see: www.teagasc.ie/training/courses.asp

- Forestry - short course and events
- Horticulture – specialised short courses
- Organic Farming
- Teagasc Options Programme

- Goat Farming
- Poultry Farming
- Artisan Food Courses
- Rural Tourism
- Rural Business
- Equine:
- Pesticides
- Milking Skills
- Internet for Farmers
- Hedgerow Management
- Mechanical Hedge Cutting Contractors Course
- REPS Five Hour Optional Countryside Management Courses
- Energy - Level 6 Certificate in Energy Crop Management (FETAC accredited minor award),
- Ruminant Nutrition - Level 6 Certificate in Ruminant Nutrition (FETAC accredited special purpose award)
- Teagasc Crop Nutrition and IASIS Crop Protection Courses - Level 6 Certificate in Crop Nutrition (FETAC accredited special purpose award)
- Discussions Groups - Teagasc has a national network of discussion groups covering all the major farm enterprises. The Dairy Efficiency Programme, Beef Technology Adoption Programme and Sheep Technology Adoption Programme are included in the Teagasc Discussion Group network.

The Economic Returns to Formal Agricultural Education

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