The role of investment, fundamental Q and financing frictions in agricultural investment decisions: an analysis pre and post financial crisis

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Abstract

This paper uses a fundamental Q model of investment to consider the role played by financing frictions in agricultural investment decisions, controlling econometrically for censoring, heterogeneity and errors-in-variables. Our findings suggest that farmer's investment decisions are not driven by market fundamentals. We find some evidence that debt overhang restricts investment but investment is not dependent on liquidity or internal funds. The role of financing frictions in determining investment decisions changes in the post-financial crisis period when debt overhang becomes a significant impediment to farm investment. The evidence suggests that farmers increasingly rely on internal liquidity to drive investment. Finally, we find no evidence that farmers use off-farm capital to fund on-farm investment.

Keywords: Credit Constraints, Firm Level Investment, Tobin's Q, Debt
JEL classification: G31, G32, F34

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1 Introduction and background

Investment is of critical importance to economic development, driving productivity and efficiency in production and enhancing firm profitability. Given this important role, there has been significant research into the determinants of investment expenditure by firms and the factors that influence their investment behaviour. This papers' contribution is twofold. First, building on research concerning investment in European agriculture (Huettel et al. (2010), Sckokai and Moro (2009), Vercammen (2007)), this paper uses Q theory (Tobin and Brainard (1976)) to evaluate the role played by fundamentals and financing frictions in determining on-farm investment. Second, the paper contributes to the methodology appropriate for analysing lumpy investment decisions by simultaneously addressing issues of censoring, heterogeneity and errors-in-variables in panel data.

One of the most important neoclassical investment models, Q theory models intertemporal investment as the adjustment to the long run capital stock such that a firm invests until the marginal benefit of an additional unit of capital equals its marginal cost. This research specifically looks at the contrasting role played by expectations about future profitability, and financial considerations namely debt overhang, liquidity and off-farm income in driving on-farm investment behaviour. It also considers the impact of changes in the credit operating environment on investment behaviour. A number of structural changes have occurred to financial and capital markets and the credit environment in Europe in the last number of years, namely the introduction of the euro as well as the recent financial crisis. This paper considers the effect of these major changes to the operating environment on access to credit for on-farm investment.

Using farm level data from Ireland over the period 1996-2009, a fundamental Q model of investment is estimated with financing frictions included in the empirical investment equation. To estimate values for Q, the GMM panel vector autoregression (VAR) approach outlined in Gilchrist and Himmelberg (1995) is used. This method has been extended to consider issues of investment in agriculture by Bierlen and Featherstone (1998) and Benjamin and Phimister (2002).

To appropriately consider the impact of financing frictions on investment in agriculture, the analysis is extended to evaluate the role played by off-farm income in determining on-farm investment. There are two possible channels through which off-farm income can impact on farm investment. Firstly, off-farm income can directly increase total internal funds. Therefore, it acts through the same channel as on-farm cash flow. Secondly, off-farm employment may improve access to debt if it is taken into account as additional income in loan applications. Empirical studies have found mixed evidence in relation to off-farm income and on-farm investment.[1] In this paper we attempt to reconcile this evidence by analysing the channels through which off-farm employment can influence financing constraints for investment.

The second contribution relates to the methodological approach as a number of econometric challenges are addressed in this paper. The nature of the data, as well as the research question under review raises three econometric issues, namely censoring of the dependent investment variable, mis-measurement in the estimate of Q and unobserved heterogeneity that arises in a normal micro-data situation. Censoring in the dependent variable is a product of the investment behaviour of firms which, especially for SME's, is lumpy and infrequent. This leads to repeated zero values on the dependent variable. Mis-measurement of the fundamental Q variable arises due to the fact that the model approximates the unobservable marginal Q with an estimate based on fundamentals. This paper uses an instrumental variables fixed effects model with the Symmetrically Censored Least Squares (SCLS) approach of Powell (1986) and Chay and Powell (2001) to cater for censoring, individual heterogeneity and errors-in-variables. This approach addresses some of the issues outlined in Huettel et al. (2010) in terms of the error structure of the tobit model.

A number of important conclusions emerge from our research. Firstly, the results indicate that fundamentals do not appear to drive investment activity. We find no evidence of positive and significant Q statistics. While the coefficient for Q is not significant in the majority of regressions, the actual sign on the coefficient is negative; the opposite to a-priori expectations. This is difficult to interpret. One explanation may be that some farmers, observing declining fundamentals, are attempting to invest to turn the position around instead of exiting the market or consolidating. Choosing to remain active in farming may be motivated by non-

[1] Hennessy and O'Brien (2008) found no evidence of capital labour substitution in Irish agriculture which other studies, outlined in section 2 found some evidence in support of the capital labour substitution hypothesis.

economic reasons such as lifestyle, tradition or other social factors.

Considering the impact of financing frictions on investment, there is some evidence that debt overhang negatively impacts on investment. This effect is greatest for middle-aged farmers. Over the whole sample, we find no impact of liquidity on investment. Farmers are not dependent on internal funds to drive investment expenditure. This is not a surprising finding for two reasons. Firstly, most farmers have a high net worth due to the large land holdings they own. These land holdings are a significant source of collateral which can be used in accessing credit from financial institutions. Our finding in terms of liquidity would corroborate the fact that, due to the high net worth, farmers are not constrained by current income or liquidity in accessing investment credit. Additionally, the period in which our data covers in Ireland is one of significant increases in the value of land which provided an additional boost to farmers' collateral. The second issue relates to the security of income from farming in the EU. The significant level of subsidisation in both pre and post decoupling environments provides income streams of relatively low risk and volatility. The security of income would reduce the risk and provide farmers with better access to debt financing. This result corroborates the findings of Vercammen (2007) who posits that direct payments may stimulate investment by reducing the risk of bankruptcy and increasing the expected value of marginal investment. This result is also highlighted in Sckokai and Moro (2009) whose research confirms the previously held intuition that the degree of profit uncertainty is a key variable determining the rate of investment in agriculture.[2]

In terms of the role played by off-farm income on investment, we find no evidence of a direct impact whereby it supplements internal funds used for investment purposes. It does not seem that farmers substitute off-farm capital for on-farm labour. There is also no evidence found in regard to the indirect channel whereby off-farm employment eases credit constraints by influencing the decision of lenders to take off-farm employment into account when making loan decisions. Contrary to this, the results indicate that for farmers with off-farm employment, debt overhang has a significant and negative impact on their investment which is not the case for those without off-farm income. It could be the case that farmers with off farm employment are less committed to farming and are running the farm for non-economic reasons. These farmers may be more sensitive to debt financing and financial institutions may

[2]Additional work on this issue can be found in Lagerkvist (2005).

be less likely to extend credit if the farmer is not running his operation as a profit maximising business.

Finally, the impact of the credit cycle on financing frictions is investigated. Our findings indicate that in the pre-crisis period, following Ireland adopting the euro currency, credit constraints did not bind and neither did debt overhang or liquidity impact on investment. This was a period in which credit was abundant in the overall economy, as Irish banks accessed international and euro credit markets with relative ease. It is no surprise that farmers, who have access to significant collateral due to their land holdings, were not credit constrained. However, since the onset of the financial crisis, both debt overhang and liquidity have become significant determinants of investment. Debt overhang is found to have a significant and negative impact on investment following the crisis while liquidity is found to have a positive impact on investment since the crisis. This indicates that farmers are now dependent on their internal funds to drive investment. It should be noted however that the financial crisis coincided with a significant reduction in the profitability of many farm operations. This may have impacted on the investment choices of farmers and also on their ability to demonstrate security of income to credit institutions. This income effect is captured in our fundamental Q variable in so far as farmers' outlook on the sector would reflect the negative conditions. This should not significantly influence the impact of credit access on farm investment although the reduction in profitability may have influenced the lending decisions of credit providers.

This paper is structured as follows. Section 2 presents an overview of the relevant literature. Section 3 outlines the empirical model of investment used in this paper. Section 4 outlines the data and considers the econometric issues of censoring, errors-in-variables and heterogeneity. The methodological approach is also presented in section 4. Section 5 outlines the main findings of the empirical assessment and section 6 concludes.

2 Background and context

One of the most important models within the standard neo-classical investment framework is the Q theory of investment. The first formal exposition of the Q model of investment was by Tobin and Brainard (1976) and was further developed by Tobin (1969) which built on Keynes' neoclassical investment theory. Erickson and Whited (2000) outline the Keynesian intuition behind the Q theory: "there is no sense in building up a new enterprise at a cost

greater than that at which a similar existing enterprise can be purchased; whilst there is an inducement to spend on a new project what may seem an extravagant sum, if it can be floated off the stock exchange at an immediate profit" (Keynes (1936) cited in Erickson and Whited (2000)). These models have subsequently formed the basis of a significant body of research into the determinants of firm level investment.

Lucas and Prescott (1971)) outline a structural model of Q theory in which the first order maximisation of the value of the firm in respect of capital choices equates the marginal benefit and marginal cost of capital. In these models, the shadow value of capital is exactly equal to the marginal cost of adjustment to the capital stock and the cost of investment capital. The shadow value of capital is known as marginal Q and represents the increment in profitability that is expected by the firms' managers resulting from a one unit increment to the capital stock. A complete review of the early literature in regard to the Q model is found in Chirinko (1993) and subsequent work is highlighted in Erickson and Whited (2000).

Despite its neat theoretical derivation, empirical studies using Q models have mainly found it to have poor explanatory power. This has led to a body of work looking at capital market imperfections and the role of information asymmetries in determining investment behaviour. This stream of research has been driven by two main concerns as outlined by Hubbard (1998). Firstly, macro concerns have focused on the fact that investment fluctuations do not seem to be purely driven by fundamentals while at the micro level significant information difficulties cause imperfections in credit allocation. The research in this area highlights the role played by external financial constraints in determining access to credit for enterprises and considers the impact of liquidity, retained earnings, and collateral on the investment decision. The general premise considered is that small firms, with relatively little access to collateral face significant external constraints in accessing credit due to a return premium demanded by the suppliers of funds. In this context, firms rely on internal sources of investment finance. The existence of this asymmetric information between the financiers and firms seeking to expand, increases the constraints on investment financing mainly due to concerns about the availability of collateral as opposed to the potential returns of the specific project that funding is required for. This drives a wedge between internal and external costs of financing which in turn impacts on firms' investment behaviour.

The empirical evidence in relation to the impact of capital market considerations on

investment decisions has provided clear results that financial issues play a significant role in determining the investment behaviour of firms. Whited (1992) finds that asymmetric information impacts financially challenged firms' ability to access financing markets and thus alters their investment behaviour. The focus on debt in this study is important due the reliance of most firms, especially SME's on debt financing. Hubbard (1998) provides a detailed overview of recent studies that focus on capital market imperfections and investment. He notes that a significant correlation exists between investment by firms and any measure of net worth or internal funds. He attributes this to capital market imperfections.

An important study in this area by Hubbard and Kashyap (1992) again highlighted the relatively poor performance of neoclassical and Q theories of investment and noted the assumption in these models of symmetry between internal and external funding for investment needed re-evaluation. They outline the role played by inside finance and its impact on external financing costs in the presence of asymmetric information in capital markets and provide significant evidence of a role for internal net worth in determining investment.

Benjamin and Phimister (2002) consider the impact of different capital market structures on access to credit in the French and UK agricultural sectors. Their results indicate that the structure of the capital market in which the firm operates impacts on the dependence of the firm on cash flow and collateral to fund investment. Bierlen and Featherstone (1998) use a panel data set for farms in Kansas over the period 1976-1992 to consider whether enterprises face financing constraints for farm machinery investment. The findings of this study indicate that credit constraints vary with business and credit cycles with the debt level being the most important determinant of financing constraints.

Huettel et al. (2010) also use Q theory to consider the impact of investment irreversibility and capital market imperfections in agriculture. Focusing on German farm level data, they estimate a Q model using a generalised Tobit structure. They find that low levels of investment do not necessarily relate specifically to agency problems or information asymmetries. They find that costly reversibility and uncertain future expectations also lead to a reluctance to undertake investment. Research into the impact of financial frictions on investment was also completed by Kuiper and Thijssen (1996).

Hennessy, Levy and Whited (2007) consider the impact of financing frictions in a structural Q investment model. They find a significant role played by financial market frictions in

determining the timing and scale of investment. Moyen (2007) uses a flexible investment model to consider the role of debt overhang in limiting new investment. Both long term and short term debt are considered and the findings indicate that underinvestment is significant with debt overhang, most notably with long term debt. Hennessy (2004) uses a dynamic real options framework to consider the impact of debt overhang on investment.

In the agricultural economics literature, one investment issue that has been the subject of much research is the role played by off-farm income in driving on-farm investment. This view posits that farmers are substituting off-farm capital for on-farm labour and maintaining on-farm output without increasing hired labour. The empirical findings in relation to this have been mixed in terms of both the significance of the relationship between off-farm income and investment and also in regard to the sign of the relationship. Hennessy and O'Brien (2007) consider this relationship in a cross sectional study of farms in the Irish dairy sector. Using a Heckman-two stage approach, they find no role for off-farm income in driving on-farm investment. Ahituv and Kimhi (2002) consider the role of heterogeneity and state dependence in the relationship between off-farm work and capital accumulation decisions of farmers. Their results outline two factors that were potentially at play, the normal substitution effect but also an expansion effect where investment increases the marginal productivity of family labour on the farm. They find that farm capital investments during the 1970s, which were enhanced by heavily subsidized credit, prevented farmers from seeking off-farm employment opportunities. Other studies including Rosenzweig and Wolpin (1993) and Upton and Haworth (1987) find evidence in favour of the substitution hypothesis.

3 Measuring Q and the empirical investment equation

Central to the estimation of Q theory models of investment is the choice of empirical proxy for the theoretical marginal Q. In this paper, the approach outlined by Gilchrist and Himmelberg (1995), and applied in an agricultural micro-data context by Benjamin and Phimister (2002) and Bierlen and Featherstone (1998), is used to estimate Q from firm level fundamentals.

Starting from the well known and widely used standard investment model, Gilchrist and Himmelberg (1995) outline an alternative methodology to obtain an estimate for unobservable marginal Q by specifying a linear forcing process for a vector, $\mathbf{x_{it}}$, of firm fundamentals.[3] This

[3] A full outline of this model and its link to the standard investment literature is presented in Gilchrist and

approach allows the estimation of a Q statistic for enterprises with no financial market listings and is therefore a very important tool for considering the role of fundamentals in farm level investment decisions. The forcing process for firm fundamentals is specified as an AR(1) stochastic vector process. The vector includes firm level fundamentals which relate to the profitability of the organisation. The panel VAR is outlined as follows:

$$\mathbf{x_{it}} = \mathbf{A}\mathbf{x_{i,t-1}} + \kappa_\mathbf{i} + \gamma_\mathbf{t} + \mathbf{u_{it}} \quad (1)$$

$$q_{it} = \left(\mathbf{c}'[\mathbf{I} - \lambda\mathbf{A}]\right)\mathbf{x_{it}} \quad (2)$$

The first equation is a system of vector autoregressions which uses fundamental drivers of investment to develop estimates of the coefficient matrix A to estimate Q. This error structure in this process is specified to include firm level heterogeneity and a time effect to control for the impact of changes to the business cycle or general economic environment on fundamentals. The second equation takes the coefficient matrix from the VAR and estimates a proxy for Q dependent on the VAR coefficients and the current fundamentals. The matrix c is an identifier for the marginal value product of capital with λ the discount and depreciation rate set by the econometrician.

In regard to which of the firm level fundamentals are included in the model, different authors have used varying combinations of fundamentals in this system. Beirlen and Featherstone (1998) and Benjamin and Phimister (2002) include the marginal value product of capital (mvpk) and total sales in their system VAR, $\mathbf{x_{it}}$. We include the mvpk [4] and the sales to capital ratio. The estimation procedure for the panel VAR uses the GMM approach outlined in Holtz-Eakin, Newey and Rosen (1988) and Gilchrist and Himmelberg (1995). This estimate for Q can then be included in the standard investment equation:

$$\frac{I_{it}}{K_{i,t-1}} = \frac{1}{a}q_{it} + \xi_i + \gamma_t + \varepsilon_{it} \quad (3)$$

$$(4)$$

I_{it} is investment by firm i at time t, $K_{i,t-1}$ is capital stock of firm i in period t-1, and q_{it}

Himmelberg (1995).

[4]Following as Bierlen and Featherstone (1998) we have defined mvpk as gross output minus total costs divided by the capital stock which basically provides a measure of the return per unit capital stock

is fundamental Q which is based on the identity presented in equation 1. The error term in the investment equation is made up of firm specific effects ξ_i, time effects γ_t and a random shock term ε_{it}.

In this paper, our focus is on estimating the impact of financing frictions on investment. The structural model developing the Q approach relies on the assumption of perfect capital markets (Hayashi, 1983) which implies that, when evaluating the profitability of investment decisions, firm managers are not constrained by issues relating to access to capital. Empirically this means that when an investment equation includes a good proxy for Q, no additional variables should be significant, including financials, if the model's assumptions are correct.

For many firms especially SME's, assuming perfect capital markets is not realistic as they face issues relating to asymmetric information in credit markets. This results in current levels of leverage, the availability of collateral and the availability of internal funds impacting on investment choices. Including financing frictions in the investment equation with Q and testing their significance provides a measure of the impact of credit constraints. We include three specific financing frictions in the empirical investment equation. The level of debt overhang is included in the model to consider whether current leverage is an impediment to accessing additional debt to fund investment expenditure. A measure of liquidity is included to pick up the role played by internal funds in financing investment. In addition, the impact of off-farm income is considered, to see whether off-farm capital is being used to either directly fund on-farm investment or whether it eases credit constraints in accessing investment debt. Our empirical specification is outlined as follows:

$$\frac{I_{it}}{K_{i,t-1}} = \alpha_0 + \alpha_1 q_{it} \pm \alpha_2 X_{it} + c_i + \eta_t + \epsilon_{it} \tag{5}$$

where

$$X_{it} = \begin{cases} \frac{D_{i,t-1}}{K_{i,t-1}} & \text{Debt overhang} \\ L_{it} & \text{Liquidity} \\ OFI_{it} & \text{Off farm employment} \\ \text{interactions of} & \text{OFI and Debt/Liquidity} \end{cases} \tag{6}$$

The a-priori expectations are outlined in table 1.

The a-priori expectation is a negative relationship between debt overhang and investment.

Table 1: A-priori expectations for main variables

Variable	A-priori sign
Q	+
Debt overhang	-
Liquidity	+
OFI	+

This reflects the negative impact of outstanding loans on access to capital for investment. If firms are credit constrained and internal funds are required for investment, the firms' liquidity position should be positively related to investment. In the case of Irish farming considered in this paper, our a-priori expectations in relation to the impact of financial constraints on investment are guided by two additional considerations. Firstly, due to the fact that farmer incomes over the period were supported by significant and regular subsidisation, the uncertainty over repayment capacity is reduced. This may influence the extent to which financing constraints bind and may reduce the requirement of farmers to use internal funds. Secondly, due to the large level of collateral and net worth in farm land holdings farmers may not face credit constraints similar to other SME's. Both of these influences may lead to credit constraints binding on average less for farm operators than for SME's in the wider economy.

Our expectations in relation to the impact of off farm income on investment is that it income should also be positively related to investment if it acts through the direct channel of augmenting internal funds. If farm operators are substituting capital for labour, then increased off-farm earnings should increase on-farm investment. If off-farm employment impacts on-farm investment through indirect channels such as being considered by lenders in loan applications, interactions with debt overhang and liquidity should be significant.

4 Data and Econometric Methodology

To estimate investment equations for SME's such as agricultural farm enterprises, a number of econometric issues are raised, specific to the nature of the data used. These issues are censoring and heterogeneity. In addition to this, estimating the Q model of investment raises further issues of developing a proxy for Tobin's Q and treating this proxy for measurement

error. This paper outlines an econometric methodology which controls for censoring, errors-in-variables and individual heterogeneity in estimating a standard linear Q model of investment. This section presents the data and outlines the econometric approach used to deal with each of the aforementioned issues.

4.1 Data

Estimating the behaviour of individual enterprises requires appropriate micro data. The data used in this paper are taken from the Irish National Farm Survey which is compiled annually by Teagasc.[5] The survey is conducted on approximately 1,200 farms and is a representative sample of the farms in the Republic of Ireland. The farm systems surveyed are as follows: dairy; dairying other; cattle rearing; cattle other; mainly sheep; and mainly tillage. The data used for this research is an unbalanced panel covering the years 1996-2009 with some farms remaining in the sample for a number of years and those that exit replaced by representative similar farms. The total sample contains some 15,700 observations.

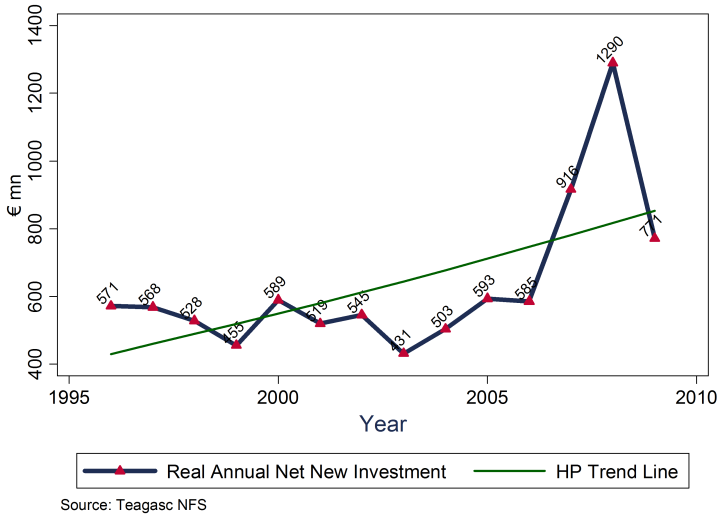
The main variables in the model relate to investment and financing frictions. For the dependent variable on business investment, the farm survey has annual values for net new on-farm investment.[6] Figure 1 outlines the total real net new investment in Ireland over the period 1996 to 2009. The figure shows that while investment was reasonably static over the period 1996-2006, a significant investment spike occurred in the period 2007 - 2008. This coincided with the significant government incentives that were offered as part of the 2007-2013 Rural Development Programme Farm Improvement Scheme as well as environmental compliance investment schemes such as the Farm Waste Management Scheme and the Dairy Hygiene Scheme which were introduced to ensure EU on-farm operating standards were met. While not the focus of this current paper, the impact of the grants on investment activity must be controlled for given its impact on the operating environment.

If farms are investing due to expected future profitability, it is reasonable to expect a correlation between investment and farm incomes. To demonstrate a potential correlation between farm incomes and farm investments, figure 2 displays real values for both of these series. As we can see from this chart, farm incomes have not been rising and the investment

[5]See Annual National Farm Survey, Teagasc by Connolly, L., Kinsella, A., Quinlan, G., and Moran, B.

[6]This is defined as "all capital expenditure during the year, less sales of capital and grants received" (Connolly et al, 2008, p.20)

Figure 1: Total On Farm Net New Investment in Ireland



spike discussed earlier does not take place against the backdrop of increasing returns. This demonstrates the impact of the government incentives on investment in agriculture.

The ratio of investment to the opening value for the capital stock in each period is used as the dependent variable for this paper. The mean value for this ratio over the sample is 0.02 which indicates investment to capital was approximately 2% on average. The measure included for debt overhang is the opening balance of debt divided by the opening period capital stock. The mean for this variable indicates an average level of leverage of 4%. This indicates that farmers were not necessarily highly leveraged over the whole sample and had significant collateral available to access debt markets. To measure the impact of internal funds or liquidity, the ratio of current interest payments to current income ($\frac{r}{CI}$) is used to capture the ability of a firm to cover its short term obligations. It is a proxy for the well known liquidity variable, the current ratio (CR). While traditional measures of liquidity would include the ratio of current assets to current liabilities, we have inverted the ratio to maximise our sample size. The intuition is therefore the opposite of what one would normally assume with studies using the CR. To cater for negative values and outliers, the distribution of this variable is trimmed, dropping the negative values and the equivalent number of observations at the top end of the data.

To assess the impact of having off-farm employment on the investment activity on-farm, we include a dummy indicator for farmers engaged in off-farm employment. As is mentioned

Figure 2: Farm Income and Farm Investment

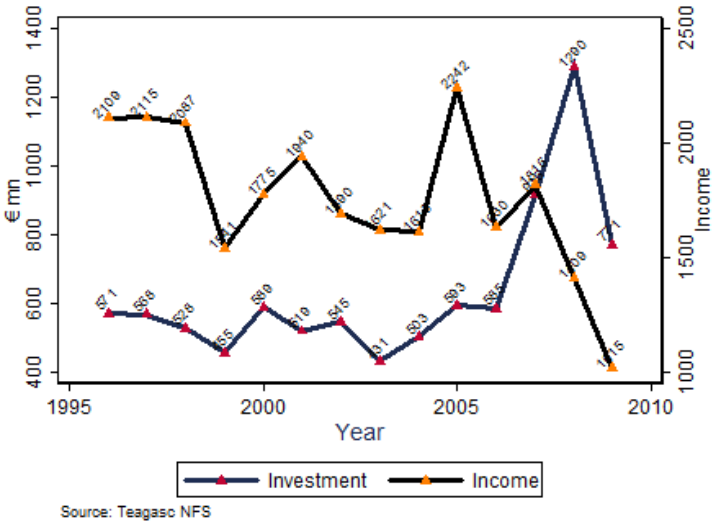


Table 2: Summary stats for key variables - Original data

Variable	Obs	Mean	Std. Dev.	Min	Max
$\frac{I}{K}$	15,618	.019	.042	0	1.069
Debt overhang	15,618	.043	.081	0	1.799
Debt overhang (LM)	12,277	.027	.063	0	1.081
Debt overhang (S)	12,277	.004	.023	0	1.114
$\frac{r}{CI}$	12,302	.090	2.975	-149.492	189.618
OFI (D)	15,655	.261	.439	0	1

Table 3: Total No of Investments

Invest (1=Yes 0=No)	Freq.	Percent	Cum.
0	5,604	35.80	35.80
1	10,051	64.20	100.00
Total	15,655	100.00	

in section 3, to estimate Q, data is required on firm fundamentals. The fundamentals that are included in our model relate to the marginal value product of capital and total sales. Following Bierlen and Featherstone (1998), we define mvpk as gross output minus total costs over capital stock.

4.2 Sample Selection

A significant issue that arises with investment data is the occurrence of zero observations on the dependent variable. Many investment programmes are lumpy and infrequent. This is particularly salient when dealing with small to medium sized enterprises and agricultural farm level data. These type of data also contain negative observations on firms that are divesting and potentially leaving the industry. These considerations raise concerns about sample selection and present challenges to standard estimation techniques. Table 3 outlines the total number of positive investments in the dataset. Over 35 percent of the observations for the dependent investment variable are zero. This highlights the problem of censoring in the investment data.

This paper uses a methodology drawing on the work of Jones and Labeaga (2002) to treat the issue of repeated zero observations and censoring. The sample is split into those farms that never invest and those that are potential investors. Non-investors are defined as those farms that post a zero investment level in all years in the sample. Potential investors may or may not have positive investment in year t but must have made at least one positive investment in the sample period. Given the relatively long period under consideration, this seems an appropriate condition for non-investment. Splitting the sample along these lines is particularly important in the agriculture sector due to the existence of hobby and part-time farmers. These individuals may not respond to market incentives and are active in the industry due to non-economic, social or historical reasons. These farmers need to be

Table 4: Summary stats for key variables - Selected sample

Variable	Obs	Mean	Std. Dev.	Min	Max
$\frac{I}{K}$	14,462	.021	.043	0	1.069
Debt overhang	14,462	.045	.083	0	1.798
DO (S)	11,660	.004	.024	0	1.114
DO (LM)	11,660	.028	.065	0	1.080
$\frac{r}{CI}$	11,682	.093	3.051	-149.492	189.618
OFI (D)	14,494	.259	.438	0	1

distinguished from active market participants whose investment behaviour is influenced by expectations regarding future profitability. This sample splitting approach removes these farms from the analysis and enables the estimation of the investment model on profit-seeking farm operators only.

Removing the non-investors potentially induces sample selection bias. Following Jones and Labeaga (2002) and Wooldridge (1995), sample selection tests are conducted whereby probit estimations (on a binary variable of 1 for investors with 0 otherwise) are used to derive the inverse mills ratio (IMR). The IMR is then included in a linear model of the investment equation. The number of persons per farm household is used as the exclusion restriction for identification of the first stage parameters. This variable is chosen given that the larger the farm household, the more likely it is that a successor exists. The potential of having a successor is likely to influence whether the farmer is an active investor or a passive farmer. Sample separation is supported by an insignificant coefficient on the t-stat of the mills ratio.[7]

Table 4 presents summary statistics for the key variables for the reduced sample. The data do not vary significantly from the previous figures for the whole dataset (table 2) nevertheless a formal sample selection test is still conducted.

4.3 Censoring

An innovation of this paper is applying sample selection techniques so as to appropriately treat the behaviour of investors and exclude those that are not investors from the sample. Having excluded non-investors, the remaining zero observations must be controlled for. In

[7]The results of this analysis are presented in section 5.

Table 5: Total No of Investments: Selected Sample

Invest (1=Yes 0=No)	Freq.	Percent	Cum.
0	4,443	30.65	30.65
1	10,051	69.35	100.00
Total	14,494	100.00	

total, out of the 14,494 observations for investment, 30 percent are zero. This is a significant number and it is imperative that an appropriate econometric technique is used to cater for this issue. Looking at the frequency of investment, it can be seen that about 9 percent of the data related to farms that made only one positive investment and over 30 percent of the data related to farmers that made three or less investments. This highlights the scale of the censoring and the occurrence of zero value observations. Using standard techniques would yield biased and inconsistent estimates so it is imperative that a censoring method is implemented.

The intuition behind using a censoring technique comes from the latent style behaviour of investment. The observed outcomes are realisations of unobservable preferences of investors. These underlying preferences may actually indicate a negative view towards investment but the only observed values are positive or zero. This view should related to the information contained in current market fundamentals. The Q model assumes that these fundamentals provide the signals to farmers regarding investment choices. It is important to pick up this latent behaviour using a censoring technique. In the context of this paper, this type of behaviour is represented by censoring from below and takes the following well known specification:

$$\frac{I_{it}}{K_{i,t-1}} = \begin{cases} \frac{I_{it}}{K_{i,t-1}} & \text{if } \frac{I_{it}}{K_{i,t-1}}^{*} > 0 \\ 0 & \text{if } \frac{I_{it}}{K_{i,t-1}}^{*} \leq 0 \end{cases} \tag{7}$$

with

$$\frac{I_{it}}{K_{i,t-1}}^{*} = \alpha_0 + \alpha_1 q_{it} \pm \alpha_2 X_{it} + c_i + \eta_t + \epsilon_{it} \tag{8}$$

Methods for dealing with censoring, such as the tobit and double-hurdle models, have become standard in the literature[8] and have been used in the agricultural context in Newman et al. (2001). However, both methods require strong distributional assumptions (for example,

[8]See Newman et al. (2003) and Keelan et al. (2008)

Table 6: **Frequency of Investment**

No of + Investments	Freq.	Percent	Cum.
1	1,609	11.10	11.10
2	1,453	10.02	21.13
3	1,364	9.41	30.54
4	1,070	7.38	37.92
5	1,230	8.49	46.41
6	1,175	8.11	54.51
7	1,150	7.93	62.45
8	1,005	6.93	69.38
9	1,012	6.98	76.36
10	761	5.25	81.61
11	911	6.29	87.90
12	627	4.33	92.22
13	749	5.17	97.39
14	378	2.61	100.00
Total	14,494	100.00	

homoscedasticity and normality of the errors) which will lead to inconsistent estimates if violated. Furthermore, when using panel data unobserved heterogeneity across units cannot be controlled for using fixed effects due to the incidental parameters problem. In this paper, we avoid these issues by using the Symmetrically Censored Least Squares (SCLS) approach of Powell (1986) and Chay and Powell (2001). This approach assumes that the latent dependent variable is symmetrically distributed around the regression function. Given that the observed dependent variable will have an asymmetric distribution symmetry is restored by symmetrically trimming the upper tail of the distribution of the dependent variable to correspond with the censoring at zero. With this transformation least squares estimation procedures, incorporating fixed effects, are valid.

4.4 Errors-in-variables and heterogeneity

Having treated the issue of censoring and sample selection that arises as a consequence of the micro data and farmers investment behaviour, an appropriate methodology must be considered to cater for the issues that arise from the estimation of the investment equation. As outlined above, estimating the Q model of investment is prone to significant measurement error. This is due to the requirement to choose an empirical proxy for marginal Q from the structural investment model. This issue is even more pronounced for small and medium enterprises and farm data due to the lack of stock and bond market data for equity and debt valuations.

Our GMM proxy for Q is subject to measurement error due to the fact that an estimate of the present discounted value of the firm is replaced by an estimate using the fundamental VAR.[9] To obtain a consistent estimate of this model, the problem of errors-in-variables must be treated correctly. Gilchrist and Himmelberg (1995) outline a method to solve this problem using an instrumental variables approach. From the theoretical model and the identifying restriction in the fundamental VAR equation,

$$\mathbf{x_{it}} = \mathbf{A}\mathbf{x_{i,t-1}} + \kappa_\mathbf{i} + \gamma_\mathbf{t} + \mathbf{u_{it}} \tag{9}$$

the following assumption provides valid lag instruments for the VAR variables to instrument the estimate of Q:

$$E(u_{it}x_{i,t-s}) = 0 \forall s > 0 \tag{10}$$

This exogeneity assumption indicates that no correlation exists between current period errors and all lagged levels of the independent variables and the expectation of their product is therefore zero.

In addition, as individual heterogeneity is present in this panel data setting, a fixed effects transformation is required to ensure consistent estimates. Fixed effects within group transformations are not valid in this setting as this would require a strong exogeneity assumption along the lines of $E\left[u_{it}/c_i, x_{i1}, .., x_{i1}, ..., x_{iT}\right]$. This would invalidate the use of lags as instruments. Therefore, in line with Gilchrist and Himmelberg (1995), a first difference approach is used to control for heterogeneity. The weak exogeneity condition that provides a basis for the selection of instruments using this methodology is

[9] See Gilchrist and Himmelberg (1995, p.550) regarding the measurement error in this GMM estimate

$$E(\triangle u_{it} x_{i,t-s}) = 0 \forall s > 1 \tag{11}$$

Given these assumptions all available years data in levels for the independent variables, the other than the first lag, are valid instruments.

5 Empirical Results

In this section, the results of the empirical investment equations are presented. The model is estimated using OLS and instrumental variables (IV) methods with robust standard errors and SCLS methods with boostrap standard errors. To ensure an adequate and representative bootstrap sampling process, 1,500 bootstrap repetitions are taken which is well above that recommended in empirical analysis.[10] The investment equation is estimated with different combinations of fundamental Q and the financing frictions: debt overhang; internal funds; and off-farm income. As well as considering the overall impact of these variables, interaction terms are included between the financing frictions and relevant time dummies, to pick up the impact of Ireland joining the euro and the recent financial crisis.

Year dummies are included in all specifications as well as dummies for the farming system. Additional control variables are also included in each model. These are cohort dummies for the age of the farmer, size of the farm and the total value of investment grants received per annum as a percentage of the capital stock. The age and size effects are standard controls included in investment equations for agricultural studies (Hennessy and O'Brien (2007)), Elhorst (1993)). These effects are created as dummies with three cohorts for each variable relating to young, median and old farmers as well as small, medium and large farms.[11] While controlling for age effects, it is pertinent to note that the investment decisions of older farmers may potentially be influenced by the existence of a successor. If a successor exists, the farm may have an active business and promising future. Older farmers cannot therefore be assumed to invest less than younger farmers and the a-priori on the sign is ambiguous given this dynamic. Investment grants are controlled for due to the significant impact that government schemes have had on Irish agricultural investment in recent years. The investment spike in 2007 and 2008 can be directly related to incentives offered during this period.

[10] See Cameron and Trivedi (2010), p.433

[11] Additional detail on the creation of the size and age cohorts is outlined in the data annex

Prior to presenting the main results, some important econometric tests are completed. The sample selection test outlined in section 4 is conducted to evaluate the impact of the restrictions imposed on the exclusion of observations. Following Jones and Labeaga (2002), we estimate a probit model on a binary variable indicating the selected sample. This regression includes our identifying variable, household size. The second stage includes the IMR in a first difference OLS model including all exogenous variables from the selected sample. The results indicate a t-statistic on the IMR of -1.16, and a p-value of 0.246. This value indicates that there is no problem of sample selection and we can proceed with the sample excluding the non-investors.

With regard to the instruments to treat the errors-in-variables problem, our exogeneity condition has highlighted the third lag of the fundamental variables as valid instruments. At first, we use the third lag of both mvpk and sales to capital and the overidentifying restrictions test conducted to test their validity. Both instruments are deemed valid by this test statistic. On inspection of the first stage regression output, the sales instrument does not have significant explanatory power as it is insignificant in nearly all regressions. Therefore the third lag level of the mvpk is used to instrument Q in the main results as it is significant in all specifications. The discount and depreciation rate λ has been set at 0.8 for this paper.[12]

5.1 Fundamentals and debt overhang

The results of the models for fundamental Q and debt overhang are presented in Table 7. The empirical model was estimated with Q alone using both the IV and SCLS methods. Debt overhang is then included in terms of both total debt as well as debt disaggregated by short term and medium to long term debt. The requirement to conduct first differences to control for unobserved farm specific heterogeneity, as well as using the 3rd lag of the mvpk to instrument Q, reduces the sample size to 6,171 observations.

[12]This value is in line with Gilchrist and Himmelberg (1995). It assumes a depreciation rate, δ, of 0.15% and a discount rate, r, of 6%. λ is calculated as $\frac{1-\delta}{1+r}$. Sensitivities have been conducted in relation to the discount factor at 0.7 and 0.9 and the results are available on request from the authors

Table 7: **Fixed Effects Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.153*	-0.966*	-0.974	-0.097	-0.907	-0.892	-0.128	-0.902	-0.894
	(0.084)	(0.587)	(0.719)	(0.091)	(0.604)	(0.723)	(0.083)	(0.597)	(0.698)
Debt overhang				-0.162***	-0.109*	-0.111			
				(0.041)	(0.064)	(0.069)			
Debt overhang (LM)							-0.131***	-0.099**	-0.100**
							(0.031)	(0.049)	(0.051)
Debt overhang (S)							-0.168***	-0.143***	-0.143**
							(0.050)	(0.055)	(0.069)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	9,433	6,171	6,171	9,433	6,171	6,171

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

Using OLS and IV techniques, the results indicate a negative relationship between Q and investment. It is significant at the 90 percent level. The impact of using the IV approach to treat the measurement error can be seen in the fact that the impact on Q increased from -0.15 to -0.93 when we move from the OLS to IV methods. The negative sign on Q is a finding that runs counter to the neoclassical theoretical framework and our a-priori expectations. One possible explanation is that farm operators observe the declining profitability and shrinking size of the agricultural sector in Ireland. This is represented by declining fundamentals. Despite this environment, farmers are disinclined to exit this industry and sell their farm holding. This choice may be driven by non-economic factors. They therefore see investing as a method of potentially reversing this decline i.e. their hope is that investing now may turn around poor profitability in the future. Some evidence of the negative link between investment and productivity in agriculture is highlighted in Kazukauskas et al. (2010). However, when we use the SCLS approach, fundamentals appear not to have a significant impact on investment but Q still retains its negative sign. This change in significance is mainly driven by the fact that the standard errors are much higher in the SCLS given the more efficient bootstrap procedure.

Debt overhang is found to be negatively related to investment and significant at the 90 percent level using the IV method. This would indicate that having outstanding debts coming into the period has a significant and negative impact on current year investment activities for farmers. However this effect becomes insignificant when we use the SCLS approach. Additional data is available on the term structure of debt from the NFS. This data does not equate fully to the total debt overhang used previously as it comes from additional survey questions but it is accurate and representative. Using both the SCLS and IV methods, medium to long and short term debt are both significant, the IV at the 99 percent level and SCLS at the 95 percent level. The size of the impact appears to be similar between IV and SCLS methods which would indicate that those farmers who did not invest (recorded zero as was discussed in section 3) faced no greater debt constraints than those who did. The parameter estimates would indicate that a 1 percent change in debt overhang leads to a 0.1 percent decrease in the investment to capital ratio for medium to long term debt and a 0.14 percent decrease for short term debt. Considering the difference between the term structure variables, it can be seen that it is actually short-term debt that has a larger impact, as measured by

the size of the coefficient. This is an interesting finding and could reflect the fact that poor short term debt management such as an over reliance on overdraft facilities and other short term facilities could be an indicator of poor credit worthiness of the borrower. This evidence indicates that leverage plays a negative role in the decisions of farmers looking to invest on the farm. However the variable is insignificant for total debt overhang using the SCLS approach.

It is interesting to split the sample up to ascertain whether certain types of farm operations are more or less impacted by the availability of credit. Two important characteristics of farms controlled for in the previous table, are the age of the farm operator and the size of the economically active farm area. Interacting the age and size effects with debt overhang, we attempt to establish whether the impact of leverage is greater for certain size farms or certain age farmers. The results are presented in Table 8.

Debt overhang has a negative impact on farmers in the mid range age. Leverage is not an impediment to investment for young farmers or old farmers. One might expect banks to be less likely to extend credit to older farmers given their closeness to retirement and ceasing economic activity in which case the result for older farmers is contrary to expectations. It is more likely however that the impact is on the demand side in the context that older farmers are not investing actively therefore do not demand credit to finance investment resulting in an insignificant effect. The behaviour of older farmers may also be influenced by the existence of a successor. If a successor is present, the financial institution may take this into account when making lending decisions and age therefore may not restrict access to capital. In regard to whether the size of the farm impacts on whether debt overhang restricts investment, one would expect larger farms with more collateral to be in a position to take on considerably more debt. Our results however indicate no significant impact of the size of the farm on the role of debt overhang in investment financing.

In general, these results point to a negative impact of debt overhang on investment but the result does not hold for all the models tested. It must be noted that the period in which we are considering was one of significant credit availability in the wider economy in Ireland and it is unlikely that farmers, within the wider credit operating environment, would have had difficulty raising capital regardless of initial leverage levels. Having significant levels of collateral in the form of land holdings, coupled with the widespread availability of capital in the economy, may explain why a stronger impact of debt on investment is not found here. The

Table 8: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.098	-0.948	-0.931	-0.096	-0.910	-0.876
	(0.091)	(0.633)	(0.759)	(0.090)	(0.604)	(0.722)
DO A1	-0.158***	0.013	0.010			
	(0.048)	(0.167)	(0.158)			
DO A2	-0.162***	-0.141**	-0.143**			
	(0.052)	(0.065)	(0.073)			
DO A3	-0.182**	-0.088	-0.087			
	(0.080)	(0.089)	(0.095)			
DO S1				0.138	-0.184	-0.187
				(0.092)	(0.153)	(0.149)
DO S2				-0.165***	-0.104	-0.106
				(0.037)	(0.069)	(0.067)
DO S3				-0.153	-0.130	-0.136
				(0.182)	(0.153)	(0.227)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	9,433	6,171	6,171

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

subsidies paid to farmers with the EU Common Agricultural Policy scheme would also have provided farmers with a relatively secure and predictable income stream. Credit providers may have seen lending on this back of this payment structure was relatively low risk.

5.2 Fundamentals and liquidity

The second financial consideration relates to the role of liquidity or internal funds on investment. To evaluate this impact we include the ratio of interest to current income. This ratio captures the ability of the firm to cover its short term obligations with its short term assets. We include income in the denominator of this metric, to avoid missing observations where

interest payments are zero. As such, if farms are reliant on internal funds to drive investment, we would expect a negative relationship between this ratio and investment. The sample size for the models including this variable falls slightly due to missing observations. The results are presented in Table 9.

Table 9: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.153*	-0.966*	-0.974	-0.134	-0.779	-0.778
	(0.084)	(0.587)	(0.707)	(0.092)	(0.583)	(0.678)
$\frac{r}{CI}$				-0.016**	-0.000	-0.000
				(0.006)	(0.018)	(0.020)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	8,764	5,775	5,775
Cells show coefficients and standard errors						
* p<0.05, ** p<0.01, *** p<0.001						

We find no significant impact of fundamentals on investment in these models. Using the IV and SCLS approaches, the results indicate that, while carrying the correct sign, there is no role for liquidity in driving on-farm investment. This indicates that farmers are not reliant on internal funds to drive investment over the whole sample. Some evidence is found for a liquidity impact using the OLS method but these estimates are inconsistent.

We also interact liquidity and both the age and size cohort effects. The results are presented in Table 10. Using the more efficient SCLS approach, it appears that neither the age of the farm operator or the size of the farm play a role in determining whether liquidity impacts on investment behaviour, thus reinforcing the findings for the whole sample.

As was noted above in regard to impact of the wider credit operating environment on debt overhang, the finding that liquidity is not a determining factor for farmers investment behaviour is not surprising. Within the period reviewed both the security of income through the EU farm payments scheme as well as the availability of credit - with their high net worth as collateral - would have allowed farmers easy access to external debt.

Table 10: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.113	-0.792	-0.795	-0.113	0.225	-0.749
	(0.092)	(0.583)	(0.698)	(0.092)	(0.161)	0.699
$\frac{r}{CI}$ A1	0.006	0.051*	0.048			
	(0.018)	(0.031)	(0.030)			
$\frac{r}{CI}$ A2	-0.040***	-0.016	-0.015			
	(0.010)	(0.019)	(0.021)			
$\frac{r}{CI}$ A3	-0.005	-0.027	-0.022			
	(0.035)	(0.032)	(0.035)			
$\frac{r}{CI}$ S1				-0.146	0.011	0.019
				(0.124)	(0.014)	(0.018)
$\frac{r}{CI}$ S2				-0.024**	-0.002	-0.003
				(0.010)	(0.019)	(0.020)
$\frac{r}{CI}$ S3				-0.024*	0.016	0.016
				(0.014)	(0.022)	(0.027)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes		Yes	Yes	Yes
n	8,764	5,773	5,773	8,764	5,773	5,773

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

5.3 Off-farm income and investment

The final financing friction we consider is the role played by off-farm income and off-farm employment in driving on-farm investment. We include a dummy for whether a farm operator has an off-farm job. There are limitations of using a dummy variable as opposed to a continuous off-farm income variable but unfortunately the data for the level of off-farm income is not robust. In this context, we focus our analysis on the dummy indicator for off-farm employment. We also include interactions with debt overhang and liquidity to establish the channels through which off-farm income impacts on-farm investment. The two main channels are, firstly, the direct channel through which internal funds are bolstered and off-farm

income is used to pay investment expenditure and, second by the indirect channel whereby off-farm income potentially reduces credit constraints as lenders take off-farm employment into account when evaluating loan proposals.

Firstly, we consider the impact of off farm income by just including the off-farm employment dummy. We also interact the dummy variable with both the age and size cohort effects to test whether these farm characteristics induce different effects. Table 11 presents the results. There is no impact of the off-farm dummy on investment using any of the OLS, IV and SCLS methods. Farmers with off-farm employment are not systematically investing more than those with no off-farm jobs.

Table 11: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.153*	-0.975*	-0.971	-0.153*	-0.967	-0.962	-0.154*	-0.956*	-.954
	(0.084)	(0.588)	(0.718)	(0.084)	(0.590)	(0.711)	(0.084)	(0.580)	.710
OFI (D)	0.000	0.001	0.001						
	(0.001)	(0.002)	(0.002)						
OFI Age 1				0.002	0.004	0.003			
				(0.003)	(0.003)	(0.003)			
OFI Age 2				0.000	0.001	0.000			
				(0.001)	(0.002)	(0.001)			
OFI Age 3				-0.001	0.001	0.001			
				(0.005)	0.006	(0.006)			
OFI Size 1							-0.002	-0.002	-0.001
							(0.004)	(0.003)	(0.002)
OFI Size 2							0.000	0.001	0.001
							(0.001)	(0.002)	(0.001)
OFI Size 3							0.004	0.009	0.008
							(0.009)	(0.012)	(0.013)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	9,433	6,171	6,171	9,433	6,171	6,171

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

When the off-farm employment dummy is interacted with the age and size controls, there is also no impact of any of the combinations. This finding indicates that off-farm employment is not a driver of on-farm investment for any of the three age categories and size categories considered. The general finding in relation to off-farm income is similar to that of liquidity. There is no evidence that off-farm employment is positively related to investment which would be expected if farmers are substituting off-farm capital for on-farm labour.

The results of the interaction between off-farm income and both debt overhang and liquidity are also considered. In the interaction models, we have included both the level as well as the interaction which splits out the impact of each specific effect and ensures the interaction is appropriately capturing its impact. The results are presented in Table 12.

Table 12: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.153*	-0.975*	-0.971	-0.082	-0.747	-0.714	-0.112	-0.778	-0.778
	(0.084)	(0.588)	(0.718)	(0.073)	(0.620)	.677	(0.092)	(0.582)	(0.709)
OFI (D)	0.000	0.001	0.001	0.001	0.002	0.002	-0.000	0.000	0.000
	(0.001)	(0.002)	0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Debt overhang				-0.131***	-0.082	-0.084			
				(0.040)	(0.054)	(0.058)			
DO× OFI (D)				-0.137**	-0.145**	-0.149*			
				(0.068)	(0.063)	(0.086)			
$\frac{r}{CF}$							-0.018	0.000	0.000
							(0.018)	(0.018)	(0.020)
$\frac{r}{CF}$× OFI (D)							-0.020**	-0.003	-0.003
							(0.010)	(0.022)	(0.023)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	9,433	6,171	6,171	8,764	5,773	5,773

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

Interacting off-farm employment and debt does not seem to support the hypothesis that off-farm employment eases credit constraints for investment. While both the off farm employment dummy and the debt overhang level effect are not significant individually, their interaction is significant and negative, at the 95 percent level for the IV and at the 90 percent level using the SCLS. This finding provides contrary evidence to the hypothesis that off-farm income eases credit constraints. It suggests that farmers that have off-farm employment are more constrained by access to finance than those that do not have off-farm jobs. This is an interesting finding to which there are a number of possible explanations. First, it may be that those farmers that have off-farm jobs have small farms thus would not have as much access to collateral to secure loans. Alternatively, farmers with high levels of on-farm debt might have obtained off-farm jobs to try and ease debt burdens. While these two explanations are not verified directly in this analysis, the result indicates that farmers with off-farm employment are more credit constrained than those farmers without. An additional explanation could be that having an off-farm job may also indicate that the farm is not profitable and/or the farmer is not fully committed to its operation. Lenders may take this into account and be less likely to provide investment finance.

Considering the interaction of off-farm employment with liquidity, no significant impact is found. The OLS estimate indicates the coefficient is significant and takes the correct sign but these estimates are inconsistent. No such effect is found using the IV and SCLS methods. Our results suggest that farmers with off-farm jobs are not dependent on internal funds to drive investment and are not directly using off-farm income to add to internal funds to pay investment expenditures.

5.4 Financial operating environment and investment

The overall financial and macro operating environment and general credit availability are both very much cyclical in nature, following the general business cycle as well as being driven by financial innovation.[13] This in turn means that credit constraints for investment are not always binding with the same intensity and the ability to obtain investment finance changes depending on the credit environment. In the course of the last decade, there have been some

[13]See Gorton (2009) of a review of the impact of financial innovation of the credit cycle in the context of impact of securitisation on financial markets

significant changes to the the financial operating environment for farmers in Ireland. This includes the recent financial crisis as well as Ireland's adoption of the euro. In recent years, Ireland has gone through a massive cycle of credit expansion and leverage followed by a near complete financial and credit meltdown. This is being accompanied by a period of significant de-leveraging and a near impossible funding environment for new business investment. In this section, we test whether financing frictions had a different impact on farmer investment behaviour for the pre-crisis Irish euro membership period as well as the financial crisis itself. It must be noted that the onset of the financial crisis coincided with a number of significant changes to the operating environment for farmers, namely a significant reduction in the profitability and returns to farming, as well as the closure of a number of government investment grant scheme's. Both of these events undoubtedly influenced the investment behaviour of farmers. Our estimate of the fundamental Q and grants control variable are included to deal with these issues.

To assess whether the impact of financing constraints differed with the overall credit environment, we use a structural break approach. We define a dummy variable for the pre crisis euro period as years 2002-2007. We have chosen 2002 as this is the year in which the notes and coins of the euro were adopted. We do not have enough data to appropriately consider the period, pre and post 1999 when the euro was adopted. There is also evidence that Irish banks did not start accessing international euro capital markets significantly until the period following the notes and coins being adopted (See Honohan (2009)).

In terms of the financial crisis, the dummy has been defined to pick up the years 2008 and 2009. Despite the fact the difficulties in international financial markets became evident in 2007, it is generally accepted that this did not translate itself into changes lending practises to the real economy until 2008. The Irish economy also grew significantly in 2007. It is therefore appropriate to define the financial crisis period as post 2007 for the purpose of this research. Both of these dummy variables are then interacted with the debt overhang and liquidity financing constraints and the levels and interactions included in the regressions. The results for the interactions with debt overhang are include in Table 13.

There is no evidence of debt overhang impacting investment prior to the financial crisis as indicated by the insignificant coefficient on the debt overhang variable using the IV and SCLS methodologies. However the findings indicate a significant and negative role of debt overhang

Table 13: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS
Q (DO)	-0.110	-0.913	-0.900	-0.097	-0.908	0.217
	(0.089)	(0.598)	(0.730)	(0.092)	(0.604)	(0.648)
Debt overhang	-0.129***	-0.072	-0.074	-0.162***	-0.136	-0.164
	(0.042)	(0.070)	(0.079)	(0.056)	(0.088)	(0.070)
Financial crisis	0.005	-0.001	-0.020			
	(0.003)	(0.006)	(0.012)			
DO × FC	-0.320***	-0.290**	-0.288**			
	(0.105)	(0.114)	(0.118)			
Pre Crisis Euro Membership				-0.007**	0.007**	-0.002
				(0.003)	(0.003)	(0.007)
DO × Euro				0.000	0.051	-0.019
				(0.082)	(0.115)	(0.103)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
n	9,433	6,171	6,171	9,433	6,171	6,171

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

on investment following the financial crisis. Given that the financial operating environment since 2008 has been, and continues to be extremely challenging, the results would indicate that access to additional credit was a significant impediment to investment for leveraged farmers since the financial crisis. Highlighting the scale of the impact is also noteworthy as the size of the coefficient quadruples following the crisis from -0.07 to -0.29. This indicates the for a 1 percent increase in the difference of opening period debt to capital reduces the difference in investment to capital by nearly 0.3 percent. This is an important finding given that the financial climate will remain challenging going forward. It indicates that since the crisis past leverage has become a significant and negative determinant of on-farm investment. The financial crisis variable itself is not significant indicating that investment was not significantly reduced in 2008 and 2009. This is demonstrated in figure 1 which displays the trend graph

for overall investment. Both 2008 and 2009 are above trend. This can be explained by the significant grants that were made available over this period for investment which meant that despite the financial crisis, farmers invested significantly in 2008 and to a lesser extent in 2009.

Considering the pre-crisis euro membership period, the results indicate that debt overhang was not an impediment to investment in this period as indicated by the insignificant coefficients for all econometric methodologies. As this was a time of abundant credit in the Irish economy and also a period in which the criteria for obtaining credit in general were loosened considerably, it is of no surprise to find that farmers were not constrained by past leverage when accessing credit. We now consider the impact of liquidity in each of these two periods. The results are presented in Table 14.

Table 14: **First Difference Regression Results**

	OLS	IV	SCLS	OLS	IV	SCLS
Q	-0.115	-0.784	-.783	-0.111	-0.767	-0.767
	(0.092)	(0.581)	(0.667)	(0.092)	(0.583)	(0.681)
$\frac{r}{CF}$	-0.013	0.023	0.023	-0.047***	-0.030	-0.030
	(0.009)	(0.019)	(0.020)	(0.013)	(0.023)	(0.024)
Financial crisis	0.010***	0.012***	-0.011			
	(0.003)	(0.003)	(0.013)			
$\frac{r}{CF}$ × FC	-0.114***	-0.156***	-0.156***			
	(0.032)	(0.040)	(0.039)			
Pre Crisis Euro Membership				-0.000	-0.011**	0.008
				(0.003)	(0.005)	(0.008)
$\frac{r}{CF}$ × Euro				0.050***	0.060***	0.059***
				(0.016)	(0.023)	(0.022)
System and Time Controls	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
n	8,764	5,773	5,773	8,764	5,773	5,773

Cells show coefficients and standard errors

* p<0.05, ** p<0.01, *** p<0.001

While the results indicate liquidity is not significant over the whole sample, the interaction of liquidity with the financial crisis is significant and negative at the 99 percent level using the IV and SCLS methods. This indicates that since the financial crisis farmers now depend on their internal funds in making investment decisions. The increase in the size of the coefficient highlights the significant impact that the financial crisis has had. For the whole sample, the parameter value is approximately 0.02 and this changes to -0.15 for the crisis period.

Looking at the pre-crisis euro membership period, we also find no significant liquidity impact for the overall sample, nor any impact for the period dummy, but the interaction is significant and positive at the 99 percent level. This is a surprising finding and difficult to

interpret as it indicates that as current liabilities grew more than current income, investment increased. In other words, as the liquidity position decreased, investment increased. The only explanation that can be taken for this is that in the pre-crisis euro membership period, farmers were in no way credit constrained and did not need to use internal funds for investment purposes.

The overall results from our assessment of the impact of the wider credit environment on the role played by financing frictions on investment indicates that in the pre-crisis euro membership period, credit constraints did not bind for farmers and there was no impact of debt overhang or liquidity on investment. However for the period since the onset of the financial crisis, debt overhang is significant and negatively related to investment and liquidity is positively related to investment. These results are in line with Bierlen and Featherstone (1998) who found that credit constraints varied with business and credit cycles.

6 Conclusion

Due to its important role in driving productivity and enhancing economic growth, significant research has been conducted into the drivers of investment. In this paper we have tested the Q model of investment to consider the impact of financing frictions in the agricultural sector using an econometric methodology which controls for censoring, heterogeneity and errors-in-variables. The financing frictions included in the model are debt overhang, liquidity and off-farm income. Debt overhang and liquidity are measures that have occupied the research interest of the mainstream investment area for some time while off-farm income is a consideration specific to agriculture. We also consider whether the impact of financing frictions changes depending on the wider credit environment taking into consideration the period following when Ireland joined the euro as well as the period following the onset of the current financial crisis.

A number of overall conclusions emerge from our research. Firstly, there is no evidence that fundamentals drive investment for Irish farmers. The empirical proxy for the Q statistic that is included in the analysis is statistically insignificant when the SCLS approach is used for all models. The sign on the Q statistic is actually negative which runs counter to the theoretical Q and our a-priori expectations. An explanation for this negative sign relates to the reaction of farmers to the declining returns to agriculture in recent years. As farmers

may be reluctant to leave a declining industry or consolidate to drive scale economies, on observing declining fundamentals, they may be attempting to invest as a way to enhance future profitability. It is also highly likely that some of this relationship can be explained by the requirement of farmers to undertake compliance based investment for environmental reasons. Due to the introduction of new environmental regulations in recent years, to continue in operation, farmers have been compelled to invest regardless of the profitability of their farm. This can go some way to explaining the falling fundamentals but increasing investment levels. However, due to the statistical insignificance of this result, it is difficult to determine the true mechanism driving these results.

In relation to financing frictions, there is some limited evidence that debt overhang, when considered on its own, has a negative impact on investment. Farmers with high levels of leverage coming into the period invest less. The result is strongest for middle-aged farmers but the impact of debt overhang does not change depending on the size of the farm. We find no impact of liquidity on investment overall in the data. Farmers are not dependent on internal funds to drive investment expenditure over the whole sample. There are a number of potential explanations as to why farmers were not subject to credit constraints over the period evaluated. Both their relatively high net worth from land holdings and the wider credit environment would have provided significant access to external capital. Additionally, the security of income provided under the EU CAP support system may have been viewed as relatively low risk and secure by lenders when evaluating loan applications. This would have facilitated access to credit. Our finding supports the work of Sckokai and Moro (2009) and Lagerkvist (2005) who note that the the security of income through policy support provides a reduction in bankruptcy risk thus facilitating access to external capital.

With regard to off-farm income and employment, we found no evidence of the direct impact whereby off-farm income supplements internal funds that are used to cover investment expenditure. This result holds with regard to the age of the farm operator and the size of the farm. Neither the dummy for off-farm employment nor its interactions with liquidity yields a significant result. There is no indication that farmers are substituting off-farm capital for on-farm labour. There is also no evidence found in regard to the indirect channel whereby off-farm employment eases credit constraints by influencing the decision of lenders to take off-farm employment into account when making loan decisions. Contrary to this, the results

indicate that for farmers with off-farm employment, debt overhang has a significant and negative impact on their investment relative to those without off-farm income. This could well be due to the fact that farmers with off-farm employment are either not-fully committed to farming or the farm operation is not profitable. In this case, credit institutions may be reluctant to provide investment finance.

The impact of the credit cycle on whether credit constraints are binding is also evaluated. The findings indicate that in the pre-crisis period following Ireland adopting the euro currency, credit constraints did not bind and neither debt overhang or liquidity impacted investment. As this was a period in which credit was abundantly available in the overall economy, as Irish banks accessed international and euro credit markets with relative ease, it is no surprise that farmers, who have access to significant collateral due to their land holdings, and secure subsidies under CAP, were not credit constrained. However, since the onset of the financial crisis, both debt overhang and liquidity have become significant determinants of investment. Debt overhang is found to be a significant and negative determinant of investment following the crisis while liquidity is found to have a positive impact on investment since the crisis. This indicates that farmers are now dependent on their internal funds to drive investment. These are important findings for the sector and, if agriculture is to develop through business investment, access to credit issues will need to be addressed going forward.

A final interesting point to note is the impact of government grants on investment. In all models, this is included as a control variable and has a significant and positive coefficient value in nearly all regressions. It is the single most important determinant in nearly all specifications. This finding highlights the role played by the policy incentives on farmers investment behaviour and requires additional research so to provide clarification on the actual impact of the investment supports and grants. If we consider the impact that the government grants had on investment in 2007 and 2008 (See figure 1), and the finding that investment has not been determined by fundamentals, it is questionable whether significant subsidisation of investment is an effective use of scarce state resources. If farm profitability and investment are not positively related, then the continued rationale for state support of investment through farm improvement schemes must be questioned. Additionally, we find that prior to the financial crisis, farmers were not financially constrained. If one of the rationales for state investment subvention is that is relieves soft budget constraints (Huettel et al. (2010)), the

evidence that farmers do not face difficulties in obtaining external credit would further erode the rational for the continued introduction of productivity enhancing investment incentive scheme's. This finding is supported by Huettel et al. (2010) who notes that, if farmers reluctance to invest simply reflects the optimal intertemporal behaviour, then the rational for state investment supports is diminished.

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7 Annex

Additional sample selection included dropping data with missing values and also with dropping a number of control outliers where age or size were misreported (only 2 observations were dropped). One farm in which the size of the farm was indicated as negative and the other where the age of the farm operator was indicated as 0.

Table 15: Number of Obs by year

Year	Freq.	Percent	Cum.
1996	1,129	7.21	7.21
1997	1,173	7.49	14.70
1998	1,097	7.01	21.71
1999	1,073	6.85	28.56
2000	1,068	6.82	35.39
2001	1,163	7.43	42.81
2002	1,145	7.31	50.13
2003	1,168	7.46	57.59
2004	1,190	7.60	65.19
2005	1,146	7.32	72.51
2006	1,137	7.26	79.77
2007	1,116	7.13	86.90
2008	1,053	6.73	93.63
2009	998	6.37	100.00
Total	15,656	100.00	

Table 16: Summary stats for control variables - Original data

Variable	Obs	Mean	Std. Dev.	Min	Max
$\frac{G}{K}$	15,618	.002	.013	0	.389
Age	15,655	51.467	12.515	0	88
Size	15,655	51.349	43.538	2.8	723.19