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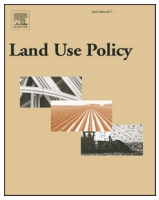
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The impact of long-term land leases on farm investment: Evidence from the Irish dairy sector

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ABSTRACT

The European Union milk quota abolition in 2015 resulted in rapid dairy farm expansion across many Member States. Continued production growth requires both capital and herd investment with secure access to land resources being important for new and expanding farmers. As land sales and rental remain low in Ireland, tax incentives to encourage long-term land rental were increased in 2015. This paper assesses the influence of the length of land leases on dairy farm investment using farm-level data from 2015 to 2018 in the context of low levels of land sales and land rental, and liberal market regulations in Ireland. We find a positive association between lease lengths and both the probability and level of capital investment which is particularly important for farmers with a high portion of land rented in. We find that herd investment is not influenced by the duration of land leases. Our findings call for an extension of policies that encourage land rental on secure leases, especially for young farmers, to increase certainty and support growth in the industry.

1. Introduction

The concept of security of tenure is centred on the legal contract between the owner of property and the occupier (Hulse and Milligan, 2014). Besley (1995) identifies four key reasons why secure rights over land encourage investment. Firstly, land rights strengthen claims to the fruits of investment. Secure tenure reduces the threat that an investment will be appropriated in the future before all its benefits are reaped. Secondly, secure land rights increase access to capital through its ability to be used as collateral. This encourages farm expansion. Thirdly, innovation is encouraged by secure rights. Lastly, access to gains from trade are achieved through secure land rights. Myyrä et al. (2007) and Arnot et al. (2011) note that land tenure insecurity in developed countries has received little attention in the economic literature despite its clear importance.

The motivation of this research is to assess the influence of the duration of land rental leases on dairy farm investment. To our knowledge, this is the first body of work to use lease length data to generate empirical findings regarding the effect of land security on farm investment in the developed world, where lease lengths are determined by the market rather than legal regulations. It is also the first paper to assess the relationship in a capital-intensive dairy farming setting.

The European Union (EU) dairy sector is the second largest agricultural sector in the EU, representing more than 12% of total agricultural output (Augère-Granier, 2018). Two-thirds of milk producing European countries increased their production between 2014 and 2020 with Ireland experiencing the greatest increase in milk production in volume terms (Eurostat, 2021; Bradfield et al., 2021a). To support future growth following the EU milk quota abolition in 2015, our research focuses on measuring investment as commercial dairy farming is a capital-intensive business that requires significant investment in capital assets such as livestock, buildings, machinery and equipment (Stokes et al., 2007; Skevas et al., 2018). Access to land also affects expansion and Loughrey et al. (2019) note that the share of agricultural land sold between 2005 and 2015 was less than 1 per cent for most EU Member States. This means that many European countries are reliant on the rental market to support expansion. It is important for this market to provide security through long-term leases so farmers can make a long-term return from their capital and herd investments.

Ireland is one example of a country with particularly low land sales with only 0.3% of available agricultural land sold in 2019 (CSO, 2020a) with inheritance being the main method of land transfer (Bogue, 2013). Therefore, farmers' access to additional land is heavily dependent on the rental market. However, the average farm in Ireland has the second

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lowest percentage of rented land in the EU at 19% compared to the EU average of 57% (European Commission, 2022)[1] and insecure, rolling 11-month conacre arrangements[2] are common (Geoghegan and O'Donoghue, 2018; Bradfield et al., 2020). This means that the improvement of land tenure security is particularly important for tenant farmers in Ireland, in addition to the fact that Ireland's dairy farms are predominately pasture based and, therefore, highly reliant on land resources. To increase the supply of rented land and lease lengths, since 2015, income tax relief of up to €40,000 is attainable for the leasing out of land on a 15-year contract (Revenue, 2021).[3] Evidence suggests that this tax relief has been effective as the number of Revenue registered cases availing of the tax exemption has increased from 5,130 in 2014 to 10,820 in 2018 (Revenue, 2020). However, the question remains as to whether the increase in lease lengths is causing a rise in farm investment, as a means to aid long-term economic sustainability. This research is applicable to many European dairy producing countries that have no regulations in place for minimum lease lengths.[4]

Using farm-level Irish Farm Accountancy Data Network (FADN) data from 2015 to 2018, the effect of land security on the decision of farmers with rented land to invest and the level of investment is examined using a Cragg (1971) double-hurdle model. Two types of investment are considered: capital investment and herd investment. This allows for comparison between fixed and liquid assets. Herd investment has direct benefits for production and capital investment can improve long-term farm performance, animal welfare, staff safety, labour and time efficiency, and farms' carbon footprint.

The remainder of the article is organised as follows. In Section 2 the literature review discusses differences in land markets in Europe and the factors, including lease length, that influence investment. Sections 3 and 4 describe the data and empirical specification. This is followed by the empirical results in Section 5, the discussion of results and policy implications in Section 6, and conclusion in Section 7.

2. Literature review

2.1. Land leasing in Europe

Van Gelder (2010) notes that the distinction between types of security of tenure is useful when considering rental systems. De jure security is based on the legal rules that enable owners to acquire, use and dispose of their property. Other types are de facto security, where occupiers may acquire greater security over time, and perceptual security refers to the occupier's perception of security. Like other European countries, Ireland is a developed country with a robust regulatory system and land security is assessed based on de jure security for the purposes of this study.

In Europe, the share of agricultural land leased by farmers varies from 17% in Portugal to 90% in Slovakia (European Commission, 2022). The explanation for such variation is the differences in historical context between countries. The reason for this high percentage in Slovakia, as well as across many parts of Eastern Europe, is that the majority of agricultural land is used by large corporate farms as opposed to family-run farms in Ireland (Swinnen et al., 2016). Under Communist regimes, land in Eastern Europe was mostly managed by large collective and State farms with most of these countries reforming their land rights in recent decades (Swinnen et al., 2016).

Marks-Bielska (2013) notes that the prevalence of land leasing in Europe results from the high purchase prices of agricultural land, which is due to the lack of supply in some areas. Swinnen et al. (2008) note that FADN data for rental markets show that the quantity of rented land is typically higher in countries with strict market regulations. Belgium and France have the highest minimum lengths of rental contracts (9 years) (Vranken et al., 2021) and the second and third highest average shares of rented agricultural land in the EU (86% and 84% in 2020, respectively) after Slovakia (European Commission, 2022), where a minimum rental period of 5 years applies (Vranken et al., 2021). In Belgium, landowners are exempt from paying income tax on land rented out on career leases. These leases are for the period of a tenant's career, with a minimum legal duration of 27 years (Vranken et al., 2021).

In France and the Netherlands, improvements in rental conditions discouraged farmers from purchasing land. Instead, capital could be used for other investments (Swinnen et al., 2016). However, there has been a recent decline in land rental in the Netherlands and France as strict regulations protecting tenants have resulted in regulated land achieving lower market prices which causes farmers to become discouraged from renting out their land (Swinnen et al., 2016).

Ireland has the most liberal land rental market in the EU (Swinnen et al., 2016; Vranken et al., 2021) and a low rate of rented agricultural land (European Commission, 2022) on short term agreements (Geoghegan and O'Donoghue, 2018). Traditionally, there is a strong desire in Ireland for land to be kept in the family name and the rental market allows farmers to generate income from unused or under-productive land without it leaving the family name of the owner. In addition to this benefit, the findings of Bradfield et al. (2020) suggest that renting in land allows dairy farms to achieve economies of scale and increase profits, and Bradfield et al. (2021b) find that a high portion of rented land increases dairy farms' technical efficiency. The dairy sector in Ireland has undergone expansion and between 2014 and 2020, the volume of land used for dairy farming increased by 13% and the average dairy farm size rose by 9% (Hennessy and Moran, 2015; Dillon et al., 2020) as farms responded to the removal of the EU milk quota.

The aforementioned recent increase in tax incentives to encourage the renting out of land on long-term leases are outlined in Table 1. Evidence suggests that the tax relief is encouraging long term land leasing as the number of revenue cases availing of the tax exemption in Ireland doubled between 2014 and 2018 (Revenue, 2020a). It is a unique incentive for farmers as Adam Smith and Henry George (George, 1879) would argue that land should instead be taxed to encourage its mobility with Ireland being one of few developed counties without a land tax (OECD, 2021). It can be argued that such a tax could instead increase land mobility and reduce deadweight loss, particularly when land use improves. The current tax relief incentives are effective in increasing long-term land leases but at a cost to the Irish State of €27.2 m in 2018 (Revenue, 2020).

Table 1
Maximum tax relief allowed each year.

Lease length	Leases entered before January 2015	Leases entered after 1 January 2015
5 to <7 years	€12,000	€18,000
7 to <10 years	€15,000	€22,500
10 to <15 years	€20,000	€30,000
15 years or more	N/A	€40,000

Source: Revenue (2021)

[1] Data from 2020 show that Portugal has the lowest percentage, at 17% (European Commission, 2022). Rented land is calculated as a percentage of utilised agricultural area.

[2] The tenant pays in cash and uses the land for one production cycle. The tenant can seek for further yearly extensions if the landowner is happy with the arrangements. There is no legal binding to let the land to the same tenant. Most conacre agreements do not involve an auctioneer (Vranken et al., 2021)

[3] Further details are shown in Table 1.

[4] EU countries with no required minimum lease length include Croatia, Czech Republic, Denmark, Germany, Estonia, Finland, Ireland, Italy, Lithuania, Poland and Sweden (Vranken et al., 2021).

2.2. Land leasing and investment

Existing research on the effects of land security on investment has led to varying conclusions. Owning more land may give farmers more motivation to invest and potentially greater access to credit, by using land as collateral (Skevas et al., 2018). On the other hand, Marks-Bielska (2013) note that the efficiency of leased land on long-term contracts under stable conditions guaranteed by law can be comparable to the efficiency of farming owned land. Swinnen et al. (2016) state that in a capital-intensive production system, farmers may prefer to invest in new technology and farm-specific assets rather than heavily investing their finances in land purchases. A minimum quantity of owned land ensures security of operation and security for long-term investments, while using rented land to expand the farm allows (financial) capital to instead be used for investment in other productive assets (Sommer et al., 1995; Swinnen et al., 2016).

In a European context, Wästfelt and Zhang (2018) examine how long-term rental contracts affect farm investment in Sweden where leases are typically of five years and there is a high level of government control. Farmers with secure leases are more likely to engage in production-related investments on leased land. Also, secure leases reduce the risk of land being used for urban activities which often generate a higher rental price. Longer leases, therefore, help in sustaining agriculture and food production (Wästfelt and Zhang, 2018). Myyrä et al. (2007) study the sugar industry in Finland where the duration of rental agreements is generally fixed at 5 years and leases over 10 years are not permitted. They find that land improvements in Finland decrease below the social optimum when the likelihood of contract renewal of a land lease reduces. Therefore, issues arise in maintaining land improvements and soil fertility that are adequate for maximising social welfare (Myyrä et al., 2007). This results ultimately in decreased output and a weakened food supply. Furthermore, land tenure security increases the efficiency of environmental schemes that aim to limit nutrient run-offs because these schemes require irreversible land investments with long pay-back periods (Myyrä et al., 2007).

In Poland, Marks-Bielska (2021) find that 84% of tenants renting agricultural land from the State note that the short duration of a lease agreement makes it difficult to plan and carry out investments on the land. 71% of tenants state that the lack of a sense of ownership over land means that a tenant is inclined to only take care of items that are expressly specified in the lease agreement. 41% of those renting land outlined that a short-term lease term can be demotivating. All of these factors influence the compliance of a tenant with the terms of a lease agreement (Marks-Bielska, 2021) which is likely to discourage the landowner from renewing a contract and the renter remains in a position of uncertainty.

Specific to a dairy setting, Sauer and Latacz-Lohmann (2015) study the benefits of investment to the dairy industry in Germany. They find that investments in innovative technology increase the productivity of dairy production. Such investments allow dairy producers to combine inputs and increase the technical efficiency of the dairy farm operation (Sauer and Latacz-Lohmann, 2015). When studying dairy farms in the Netherlands prior to the EU milk quota abolition, Samson et al. (2016) find a negative association between farm size and the likelihood of expansion, and a positive association between the portion of owned land and the likelihood of expansion. The length of leases is not assessed, however.

Existing literature has not included an analysis of lease length data to generate empirical findings regarding the effect of land security on dairy farm investment in the developed world, where lease lengths are determined by the market rather than legal regulations. We hypothesize that a positive relationship exists between the length of dairy farms' land leases and both the probability of investment and the level of herd and capital investment.

Our research assesses capital investment for all uses on dairy farms and, although it is not the focus of our research, it can be expected that investment in capital that benefits the environment is encouraged through certainty over land use. Tseng et al. (2021) state that approximately two-thirds of the 117 studies they assess find a positive relationship between land tenure security and environmental outcomes or human well-being. This is of major importance to all countries as concerns over environmental protection are heightening,[5] as evidenced by the Paris Climate Agreement and the European Green Deal which calls for investment in environmentally friendly technologies and more energy efficient buildings with the 'Farm to Fork' strategy seeking to make food systems more sustainable and environmentally friendly (European Commission, 2020a; Bradfield et al., 2021a).

2.3. Other factors influencing farm investment

The effect of land lease length on investment is the main focus of this article. In order to accurately measure this potential relationship, other variables are controlled for within the econometric analysis. These attributes, as advised by existing literature, include farmers' age, debt, direct payments and labour. These are discussed in turn below.

2.3.1. Age

There are mixed findings on the influence of a farmers' age on farm investment. Gardebroek and Lansink (2004) note, when studying Dutch pig farms, that older farmers tend not to invest and will only invest in their farms if the marginal benefits of investment are high. Kallas et al. (2012) find, when the studying Spanish cereal oilseed and protein sector, that farmer's age shows a positive correlation with investment. This is explained by the fact these farmers are likely to be experienced and not limited by credit constraints.

Successors on family farms encourage decision makers to take actions with longer time horizons compared to farms with no successor present (Calus et al., 2008; Wright and Brown, 2018). However, Skevas et al. (2018) note that the presence of a successor may motivate decision-makers to over-invest in fixed assets, which is measured as a deviation from optimum investment, to ensure the successor gains a fully equipped farm.

2.3.2. Debt

The influence of a farm's debt-to-asset ratio on investment in capital assets appears to also be inconclusive (Skevas et al., 2018). High debt-to-asset ratios may limit farmers' ability to successfully apply for investment loans and they may be indicative of greater financial risks, reducing the capacity to invest. Highly liquid resources allow for greater financial flexibility (Oude Lansink et al., 2001; Skevas et al., 2018), which encourages investment. On the other hand, Gardebroek and Lansink (2004) find that higher debt-to-asset ratios can reflect a low degree of risk aversion and therefore increase the likelihood of investment.

2.3.3. Direct payments

If farmers face credit constraints, O'Toole and Hennessy (2015) find that as income from risk-free subsidies increases, access to credit improves. Therefore, subsidies and direct payments provide a channel towards increasing farm investment. Skevas et al. (2018) hypothesize that support payments such as subsidies and direct payments lead to over-investment in fixed assets due to the added income such payments provide. However, increasing subsidies and direct payments can result in farmers becoming less motivated to replace their fixed assets, leading to a decline in the level of over-investment (Skevas et al., 2018). When analysing Irish and Dutch dairy farms that intensified and expanded production between 2008 and 2013, Lapple and Sirr (2019) find that

[5] Capital investment can be viewed as important for improving environmental measures such as investment in improved water quality, better slurry capture and energy efficient buildings.

there is little difference between the average and highly intensifying/expanding dairy farms in Ireland in terms of support from direct payments.[6] In contrast, dairy farms in the Netherlands that highly intensified/expanded during this period have lower direct payment support rates than the average Dutch dairy farm. Differences in debt ratios are likely to be driving the contrasting effects of direct payment on investment in these countries as expanding Dutch dairy farms have a debt ratio[7] of 0.36 compared to 0.05 on such farms in Ireland (Lapple and Sirr, 2019).

2.3.4. Hired labour

Skevas et al. (2018) argue that employing more labour may reduce the need for farmers to purchase new equipment to perform certain agricultural practices on Dutch dairy farms. Oude Lansink et al. (2001) support this by finding that the number of family members has a positive effect on the likelihood of Dutch horticulturist farms making investments. They also find that the presence of family members reduces business risks by reducing costs and their labour contribution generates income. However, farms with a large portion of family labour may be more risk adverse, which can negatively impact the decision of to invest (Oude Lansink et al., 2001).

3. Data

This study uses data from the Irish Teagasc National Farm Survey which includes approximately 900 farms annually across six farming systems. The data included in this study includes details of 330 specialised dairy farms in 2015, 324 in 2016, 309 in 2017 and 311 in 2018. The survey is operated as part of the EU FADN. It includes a representative sample of farms in Ireland with a standard output of greater than €8,000, the equivalent of 4 cows, selected in conjunction with the Central Statistics Office. The Teagasc National Farm Survey collects data from a stratified random sample of farms annually, with each farm in the survey assigned a weighting factor from the Central Statistics Office. Weighting the data is the basis for calculating estimates for all dairy farms in Ireland. There is a population of 17,000 dairy farms. The survey records information provided by individual farms. Therefore, it cannot capture informal rental agreements or cash transfers that a farmer may choose not to disclose. We validate the data on land parcels and lease lengths using the Land Parcel Identification System.

We focus on dairy farms in the period from 2015 to 2018 to analyse data following the introduction of increased tax incentives for long term leasing in 2015. 2015 is also the year the EU milk quota was abolished. The dataset in this study is an unbalanced panel. 96% of farms in this study complete the survey for at least two consecutive years, demonstrating a low level of sample attrition.

26% of farms in the dataset are 100% owned. Only one farm in the dataset is fully rented, highlighting its rarity. On farms with rented land, the median percentage of rented land is 27% of total land farmed. As farms in the data rent in land on multiple leases, a farm's 'lease length' is calculated as follows (Bradfield et al., 2023):

$$\sum\left(t * \left(\frac{a}{r}\right)\right) \quad (1)$$

Where t is a land parcel's rental term.

a is the area of the parcel, in hectares.

r is the volume of rented land on the farm, in hectares.

A breakdown of renting farms' land leases is displayed in Table 2.

The percentage of farms with a weighted lease length of 1 year is declining over time. However, conacre arrangements remain the most common rental agreement, despite the tax incentives that are available for the renting out of land on longer leases. Five-year contracts, which are the minimum length a lessor has to commit to in order to avail of income tax relief, are the second most common type of contract. It is clear from these data that very few landowners were receiving the full tax relief available or the benefits of certainty that these contracts provide in this period.

Table 2
The frequency of renting farms by weighted lease length.

Lease Length	2015	2016	2017	2018	Total
1 year	0.83	0.78	0.73	0.78	0.77
2.8 years	0.00	0.00	0.00	0.00	0.00 (one farm)
5 years	0.07	0.09	0.13	0.12	0.10
6–9 years	0.04	0.05	0.06	0.05	0.06
10–14 years	0.05	0.06	0.06	0.03	0.05
15 years or more	0.01	0.02	0.02	0.02	0.02

Data Source: Teagasc National Farm Survey (2015–2018)

Table 3 shows the mean levels of farm investment between 2015 and 2018 on dairy farms, regardless of whether they contain rented land or not. Average herd investment was highest in 2015. Central Statistics Office figures show that the number of dairy cows in Ireland increased by 8% between 2015 and 2016. This followed increases of 5% and 6% between 2013 and 2014 and between 2014 and 2015, respectively, (CSO, 2020b) in preparation for milk quota abolition. There was a fodder crisis due to difficult weather in 2018 (Falzoi et al., 2019) which explains the low level of mean herd investment that year. Mean capital investment increased over the same four-year period.

Table 4 outlines the frequencies and means of variables for farms that are fully owned and those which contain rented land. Farms with rented land are larger, on average. Both capital and herd investment are more common on farms with rented land, when compared to farms that are fully owned. Capital and herd investment on renting farms is also higher in absolute and per hectare terms.

The focus of the remainder of this paper is the analysis of data from dairy farms that rented in land between 2015 and 2018. These data include 245 farms in 2015, 235 in 2016, 230 in 2017 and 236 in 2018. The definitions of additional variables included in this study and summary statistics of renting farms are outlined in Table 5. Much investment occurred prior to 2015, in preparation for the EU milk quota abolition, which is accounted for by examining debt as a ratio of existing assets. Skevas et al. (2018) also examine debt-to-assets in their analysis of under and over-investment on Dutch dairy farms. A variable representing eligibility for the Young Farmer Scheme is included in the model. In the EU, a farmer of 40 years or younger with a recognised qualification in agriculture can avail of a 60% grant for capital investment under the Targeted Agricultural Modernisation Scheme (TAMS) up to a maximum of €80,000 (Government of Ireland, 2021).[8] For older farmers, the grant is 40% of the investment. This creates an added incentive for a young farmer to make large capital investments. To account for the possibility of successors being registered as the current lead

Table 3
Mean farm investment on all dairy farms (€).

	2015	2016	2017	2018
Herd investment (€)	6,665	3,223	2,586	903
Capital investment (€)	16,886	15,531	23,453	26,620

Data Source: Teagasc National Farm Survey (2015–2018)

[6] Total subsidies divided by total output.

[7] Total liabilities divided by total assets. Total liabilities = closing valuation of total loans still to be repaid; total assets = fixed + current assets.

[8] Capital eligible under this scheme include animal housing, manure pits and concrete tanks, automatic slurry scrapers, enclosures and fencing, dairy building and equipment, energy efficiency measures and tillage sector building work and equipment (Government of Ireland, 2021).

Table 4
Summary statistics (means).

	100% Owned	Renting Farms
Farms investing in capital*	0.68	0.79
Farms investing in the herd*	0.51	0.62
Capital investment per ha (€)	260.77	327.46
Herd investment per ha (€)	-41.22	58.90
Land farmed (ha)	52.10	64.21

Data Source: Teagasc National Farm Survey (2015–2018)
* Frequency.

Table 5
Variable definitions.

		Mean	Std. Dev.
Dependent Variables			
Capital investment per ha (€)	Capital expenditure during the calendar year minus capital and sales and capital grants, divided by the land farmed. This includes major repairs to farm buildings and machinery, and land improvements.	330.11	472.93
Herd investment per ha (€)	The change in the value of the herd in the calendar year, divided by the land farmed.	92.49	130.77
Independent Variables			
Lease length	The years of a farm's land lease, weighted as per Eq. (1)	2.48	3.55
Percent rented in	Rented land divided by total land farmed.	0.29	0.18
Land farmed (ha)	All owned and rented in land, minus land rented out.	64.21	34.51
Capital grants per ha (€)	Grants for machinery and building improvements, divided by the no. of hectares farmed.	16.40	73.47
Debt to asset ratio	Debt divided by the sum of values of machinery, buildings and buildings and livestock, at year end (lagged).	0.24	0.36
Basic Payments Ratio	Previously known as the Single Farm Payment. The value of the payment received, divided by family farm income (lagged by 1 year).	0.35	3.33
Hired to family labour ratio	The no. of paid labour units divided by unpaid labour units (lagged by 1 year).	0.17	0.19
Young farmer	=1 if any household member is < 45 years old. A proxy for short versus long term farm objectives.	0.48*	

* The proportion of farms that are in this category.

farmer to avail of this TAMS scheme, within this study a farm is noted as being applicable if the registered farm holder or any household member, of working age, is eligible for the scheme. The role of farmers' age and farm succession on investment decisions are discussed in Section 2 as they relate to the traits and attitudes of a young farmer. However, only one variable, which denotes the presence of a young farmer, is included in the model to avoid collinearity issues. Data on household members are collected within age categories. Therefore, in this study, those aged 44 years or younger are deemed a young farmer. Hired labour is measured as a ratio of family labour. If both variables were included in the model separately, they are likely to be correlated due to scale effects.

We examine the influence of time dummies on the decision to invest and investment levels. This assessment also reflects farm income levels which fluctuate from year-to-year due to weather and volatile market conditions. 92% of renting farms in this study invest in either capital or the herd which represents the high portion of farms that invest and the low likelihood of sample selection bias that may arise if only a small percentage of farms invested in this period.

4. Empirical model

Capital and herd investment are considered separately on Irish renting dairy farms. Capital investment involves high financial and opportunity costs given the expense and often fixed nature of capital, for example, housing and milking facilities. Herd investment represents a relatively low financial cost and the opportunity cost is minimal due to the ease at which livestock can be sold, should investors wish to reverse their investment. These two forms of investment are analysed on a per hectare basis to account for potential scale effects.

A Tobit model (Tobin, 1958) was initially considered for our empirical analysis but it assumes that the effect of a variable on the decision to invest will also have a similar effect on the level of investment (Aramyan, 2007). This is not found to be the case in our study as that the effects of the variables differ between the Probit and the truncated regression models, and log-likelihood tests confirmed this. Therefore, the Cragg (1971) alternative to the Tobit model is more appropriate.

Cragg's (1971) Tobit model alternative, also known as a double-hurdle model, is used to analyse datasets that contain a considerable number of zero observations, which are evident in our dataset. Farms with zero or negative levels of investment are considered as zero observations. In 2015, 80% of farms invested in capital and 79% invested in their herd. These figures were 74% and 62% in 2016, 85% and 63% in 2017, and 85% and 53% in 2018, respectively.

The first step of Cragg's (1971) Tobit model alternative is a Probit model to analyse the determinants of participation and the second step is a truncated model for the determinants of the level of participation (Verkaart et al., 2017). In this case, the Probit model (step 1) is used to examine the factors that influence the decision to invest.

$$\Pr(N_i = 1|Z_i) = \Phi(B_0 + B_1 X) \quad (2)$$

where *Pr* (N_i=*1*) is the probability of investment (*N*) in farm *i*. N = 1 if investment> 0. Φ is the normal cumulative distribution function and X is a list of explanatory variables.

Like Aramyan et al. (2007), the Probit model in our study is estimated using the Random Effect Maximum Likelihood estimation method. The use of random effects requires the assumption that the random effects (farm-specific unobserved heterogeneity effects) are not correlated with the explanatory variables in the model. This is a restrictive assumption, particularly in the context of the model we are estimating where farm-specific variables, such as farm and land rental characteristics, are likely to be correlated with the unobserved heterogeneity. To account for a possible correlation between unobserved heterogeneity (random effects) and the independent variables, we adopt a similar approach to Chamberlain and Ricker-Gilbert (2016) and Verkaart et al. (2016) by including the farm-level averages of time-varying independent variables (such as land rental, rental term, debt, labour, grants et cetera) in the model to control for unobserved time-constant heterogeneity,[9] under the assumption that such heterogeneity is correlated with the time-averages. This is known as the Mundlak (1978) approach.

Mundlak and Breusch and Pagan Lagrangian multiplier tests confirm that the data should be treated as a panel and not pooled. It is not possible to use weights in the models as they are not consistent across years.[10] Ramsey reset tests confirm that the regression models have no omitted variables which reduces measurement error. The causal relationship between investment and some independent variables may not be clear. Therefore, like Skevas et al. (2018), we include the opening valuation of several variables in our models to avoid potential endogeneity problems. In consequence, existing debt, hired labour and reliance on subsidies are reported as lag variables from the prior year. This

[9] Examples may be location, soil quality, risk aversion etc.
[10] The model is run using Stata software and weights must be constant within panel data when running either stage of the Cragg double hurdle model (Stata, 2023a, 2023b).

prevents endogeneity due to reverse causality or simultaneity. Heterogeneity is reduced by the inclusion of only specialist dairy farms in Ireland which include rented in land. Similar to the model presented by Kazukauskas et al. (2013), the Probit model is written as follows:

$$\Pr(invest = 1|z_i, x_{it}, \bar{x}_i, a_i) = \varphi(z_i B + x_{it} y + a_0 + \bar{x}_i(\Psi + a_i)) \quad (3)$$

where z_i are farm-specific time-invariant variables, x_{it} are farm-specific time-variant variables, $\bar{x}_i$ is the average of x_{it} for each farm over time. We assume that time invariant a_i is distributed as $N(0, \sigma_a^2)$ and is uncorrelated with x_{it} and other time invariant exogenous variables. a_0 is the constant term.

The second step of the model involves a random effects truncated regression model which is used to measure the level of investment. Farms with no investment are not included in this step of the model. These truncated observations account for 23% of the sample when capital investment is considered and 36% when herd investment is analysed. Farm-level averages (as known as group means) of time-varying independent variables are also included in the truncated regression model, to control for unobserved time-constant heterogeneity. The model is as follows:

$$LogY_{it} = Bj_{it} + K_i + \bar{j}_i + e_{it} \quad (4)$$

where y > 0.

where Y represents the level of investment, j_{it} are farm-specific time-variant variables, K_i are farm-specific time-invariant variables $\bar{j}_i$is the average of j_{it} for each farm over time. e_{it} is the error term.

The dependent variables of the level of herd and capital investment are logged. Variance Inflation Factor tests confirm that multicollinearity is not evident. The square of each continuous independent variable is included to test for non-linear relationships. A limitation of our study is the unavailability of lease length data prior to 2015 and we do not have data on the start date of leases. The security of a renting farmer's land resources is dependent on a combination of the volume of land in use, its ownership status and the length of time for which the farmer has use of the rented land. Therefore, interaction variables are included as independent variables to determine if the percentage of land that is rented or the total size of the farm affects how the lease length influences the investment of a renting farmer.

5. Results

The results of the Probit models are outlined in Table 6. These results represent the factors that influence the probability of investing in either capital or herd investment which include variables on the portion of rented land and the length of leases.

5.1. Decision to invest

77% of farms in the study invest in capital and the decision to invest can involve any level of capital investment. Table 6 shows that the probability of capital investment rises as the length of a land lease increases. The coefficients of interaction terms in a Probit model cannot be interpreted directly (Ai and Norton, 2003). Therefore, we carry out postestimation analysis and we find that as the percentage of rented land increases, it initially decreases the positive association between the lease length and the probability of capital investment. However, at high levels of rented land, as the percentage of rented land rises, it increases the positive impact lease length has on the probability of capital investment. This suggests that farms with a high portion of rented land on long-term leases are highly likely to invest in capital. Initially, as the basic payments ratio increases, there is a negative association between this ratio and the probability of capital investment. However, when the basic payments ratio is high, there is a positive association between this ratio and the probability of capital investment.

The data show that 64% of farms in the study invest in their herd. Of the many socio-economic indicators assessed in Table 6, none have a statistically significant impact on the decision to invest in the herd and, therefore, a table of results is not reported. Herd investment is customary to dairy farming, its relatively cheap and it can be easily reversed, which may explain why no socio-economic factor influences farmers' decisions.

Table 6
Determinants of participation in farm investment (Probit Model).

Capital investment	Coeff.	Robust Std. Err.
Land lease length	0.81 * *	0.33
Land lease length^2	-0.02	0.03
Percent rented in	-3.14	6.66
Percent rented in^2	2.08	0.11
Farmed land	0.02	0.00
Farmed land^2	0.00	1.56
Land lease length*Percent rented in	-3.11 * *	2.16
Land lease length* (Percent rented in)^2	4.52 * *	2.16
Land lease length*Farmed land	0.01	0.01
Land lease length* (Farmed land)^2	-0.00	0.00
Debt to assets (lag)	-1.36	1.52
Debt to assets (lag)^2	0.18	0.39
Basic payments ratio	-2.47 *	0.16
Basic payments ratio^2	2.92 *	0.59
Hired labour ratio (lag)	0.75	0.27
Hired labour ratio (lag)^2	0.21	0.33
Capital grants per ha	0.00	0.03
Capital grants per ha^2	-0.00	6.66
Young farmer	-0.39	0.13
2015 (ref.)		
2016	-0.18	0.17
2017	0.22	0.19
2018	0.19	0.18
Constant	-0.82	0.52
Rho	0.27	0.06
Observations: 516.		

Statistically significant: * **at 1% level; * *at 5% level; *at 10% level.
Group means of time-variant independent variables are included in the model but not reported.

Table 7 includes the results of truncated regression models that examine the effects of independent variables on the level of capital and herd investment per hectare. The dependent variables are in log format and semi-elasticities are reported. The rho shows the ratio of panel-level variance to the total variance within the model.

5.2. Level of capital investment

Table 7 shows the relationship between independent variables and the level of capital investment, following the truncation of farms that choose not to invest. The data indicate that capital expenditure rises as the length of land leases increases. The interaction between lease lengths and the percentage of rented land is also significant, with increases in the portion of rented land initially decreasing the positive association between lease length and capital investment. However, a high portion of rented land increasing the positive association between lease length and capital investment. Increasing farm size marginally decreases the positive impact of lease length on capital investment. This can be explained by the assumption that larger farms may contain a greater volume of owned land, making the farmer less dependent on long-term leases for security. There is a positive association between capital grants and capital investment.

All other things being equal, young farmers do not significantly invest more in capital which is surprising given the grants that are available for this specific age group. Capital investment is highest in 2018, showing a lag effect from the large increases in herd investment that occurred as an immediate response to the EU milk quota abolition in 2015.

Table 7
Truncated regression model, reporting semi-elasticities[a].

Capital investment per ha	Coeff.	Std. Err.	Herd investment per ha	Coeff.	Std. Err.
Land lease length	0.79 * *	0.34	Land lease length	-0.04	0.24
Land lease length^2	0.04	0.03	Land lease length^2	0.03	0.02
Percent rented in	3.58	5.70	Percent rented in	2.23	4.98
Percent rented in^2	-7.02	11.13	Percent rented in^2	-11.19	9.74
Farmed land	0.01	0.08	Farmed land	0.08	0.11
Farmed land^2	0.00	0.00	Farmed land^2	0.00	0.00
Lease length* % rented in	-2.27 * *	1.00	Lease length* % rented in	-0.42	0.60
Lease length* (% rented in)^2	2.63 * *	1.24	Lease length* (% rented in)^2	0.93	0.76
Lease length*Farmed land	-0.01 *	0.01	Lease length*Farmed land	0.00	0.00
Lease length* (Farmed land)^2	0.00	0.00	Lease length* (Farmed land)^2	0.00	0.00
Debt to assets (lag)	-0.68	1.09	Debt to assets (lag)	-0.03	0.94
Debt to assets (lag)^2	0.60	0.58	Debt to assets (lag)^2	0.09	0.54
Basic payments per ha	0.08	0.08	Basic payments per ha	0.59	0.67
Basic pay. per ha^2	0.00	0.00	Basic pay. per ha^2	-0.01	0.02
Hired labour ratio (lag)	0.38	1.31	Hired labour ratio (lag)	-1.30	1.39
Hired labour ratio (lag)^2	-0.48	0.73	Hired labour ratio (lag)^2	1.04	0.74
Young farmer	0.19	0.32	Young farmer	-0.08	0.31
Capital grant per ha	0.01 * *	0.00			
Capital grant per ha^2	0.00	0.00			
2015 (ref.)			2015 (ref.)		
2016	-0.18	0.20	2016	-0.62 *	-0.62
2017	0.31	0.21	2017	-0.81 *	-0.81
2018	0.51 * *	0.22	2018	-1.02 * **	-1.02
Constant	3.67 * **	0.54	Constant	4.89	0.34
Rho	0.25		Rho	0.05	

Uncensored observations: 399 Uncensored observations: 330
Statistically significant: * **at 1% level; * *at 5% level; *at 10% level.
Group means of time-variant independent variables are included in the model but not reported
[a] A one unit increase in an independent variable causes x% increase in investment per hectare.

5.3. Level of herd investment

Herd investment has been declining since its peak in 2015 following the EU milk quota abolition, which represented the most significant change to EU policy for dairy farmers this century. Herd investment per hectare is not influenced by the length of land leases or any socio-economic characteristic of a farm. This suggests that security of leases is less important for liquid assets and that herd investment is such an inherent part of dairy farming that no one factor will influence it, other than the time period which can be a proxy for weather and market conditions.

5.4. Age

Neither the probability nor the level of either type of investment is influenced by the presence of a young farmer which may be interpreted as a warning sign for inter-generational renewal because investment provides an indication of the desire of young farmers, and likely successors, to invest in the future of the farm. Our results find that there is a positive association between capital grants and capital investment. Our data show that 11% of renting farms with a young farmer receive a capital grant, which is notably higher than the 7% of farms with no young household member farms that receive capital grants. This finding provides some evidence that capital grants provided to farms with a potential successor can encourage capital investment. Increased incentives to encourage investment among young farmers is important for the continuation of the agri-food sector which is paramount in supporting the food supply chain, inter-generational renewal and rural development.

6. Discussion

6.1. The length of land leases

Our findings show that, when compared to farms that are fully owned, more renting farmers tend to invest in their herd and capital, and their mean levels of both investments are higher (Table 4). A mix of owned and rented land provides a combination of security and flexibility, as noted by Swinnen et al. (2016). A portion of owned land is important for farmers who do not wish to locate capital investments such as buildings and machinery directly on the leased land.

Our results show that the probability of capital investment on renting dairy farms rises as the length of land leases increases. There is also a positive association between the length of leases and the level of capital investment. This is increasingly evident when a farm has a high portion of rented land. This provides empirical evidence that the security of use of rented land for a longer period can increase investments in a dairy setting. By analysing data from the post-EU milk quota era and including lease length as an independent variable, our study furthers that of Samson et al. (2016) who also assess dairy farm expansion. Our research also follows previous work in other farming systems that note how lease uncertainty reduces investment (Myyrä et al., 2007; Goldstein and Udry, 2008; Wästfelt and Zhang, 2018).

The probability of herd investment is not affected by the length of leases and the level of herd investment is only influenced by the time period. This highlights that tenure security is less important to the decision to invest in the herd. This is because dairy cows are a liquid asset that can be easily sold if a land lease is discontinued.

Within this study, only 23% of farms are renting land for a duration of 5 years or longer which questions the investment levels that may be achieved if more farmers were to rent land on long term leases or if existing renters were to rent land for longer periods. It also calls for potential future research if the uptake in longer-term leases increases. The introduction of minimum durations for rental agreements could be considered as it has increased the quantity of rented land in some European countries. However, it is not clear if a *'one size fits all'* approach is best when land and farmers' requirements vary, and it is possible that minimum term contracts may prevent some land from entering the land sales market and creating full tenure security within this timeframe. Evidence from France and the Netherlands suggests that regulations that are very strict can discourage farmers from renting out their land (Swinnen et al., 2016). Increased tax incentives may be a more suitable alternative to achieve greater security of land by enticing more farmers to rent out their land for longer periods if they feel renting out land provides the lowest opportunity cost. A requirement for land to be actively farmed, as implemented in Norway (Forbord et al., 2014), should also be considered as it encourages farmers to rent out idle or underutilised land.

7. Conclusion

The objective of our research is to add empirical findings to existing discussions on the effect of agricultural land lease lengths on investment, which has been predominantly centred on the developing world, and to specifically apply this discussion to dairy farming in a developed country context. This research is relevant to countries experiencing low

agricultural land sales and a reliance on short-term rental agreements. Investment is vital for important farm objectives such as economic sustainability, labour and time efficiency, and a reduction in farms' carbon footprint.

We find a positive association between the length of land leases and both the probability and level of capital investment on dairy farms in Ireland. The length of leases becomes even more important when farms contain a high percentage of land rented in. This endorses the approach of policymakers in Ireland and calls for other governments to encourage the uptake of long-term leases. More countries could consider adopting Irish policies for taxation treatment given that minimum duration regulations are sometimes found to be too restrictive. Improved certainty over rented land encourages capital investment as considerable time may be required to reap its full benefits, especially in the case of capital investment. Long-term leases provide certainty to farmers in an industry that is susceptible to volatile milk prices, unpredictable weather conditions and insecure food supply chains. Land lease lengths do not impact herd investment which highlights their greater importance for expensive, long-term, irreversible investments.

Our research assesses the actions of young farmers and finds that, when compared to other farmers, they are no more likely to invest in their herd or capital. Young farmers are crucial to the continuation of farming practices and knowledge, with inter-generational renewal being a key objective of the EU CAP (European Commission, 2020b). The results suggest that capital grants should be extended to support young farmers. As there is a positive association between capital grants and capital investment, we assume that capital grants encourage investment in capital with environmental benefits.

In summary, the findings of this research are applicable to regions and farming sectors that are restricted by low land sales. Long-term land leases provide farmers with incentives to invest in productive fixed assets by providing certainty. This certainty can also provide security for employees. Policy initiatives that encourage tenure security and investment by young farmers should be extended to increase investment incentives. Further potential research could examine the effects of long-term leases on investment in future years as we expect more farmers will take up longer leases, providing a data source with greater variation in lease lengths. Future research may also determine the types of capital farms invest in and the optimal lease length for investment and productivity.

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Declarations of interest

None.

Data Availability

Data will be made available on request.

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