

Income Volatility on Dairy Farms in Ireland

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Abstract

Income volatility on Irish dairy farms is an established and growing phenomenon. In this paper, we use panel data from the Teagasc National Farm Survey to analyse the recent evolution of farm income volatility on Irish dairy farms with a view to identifying appropriate risk management tools for the Irish context. We place a particular emphasis on the frequency of large declines in farm income as defined under European regulations. We outline the association between direct payments and farm income volatility. We describe the availability of fixed milk price contracts, which are one of the few available farm income risk management tools for dairy farmers in Ireland. We provide a comparative analysis regarding the performance of farms, which adopt these contracts and the farms which do not adopt such contracts. Our findings show that the recent increase in income volatility is evident across the dairy farm income distribution and that there is an association between direct payments and farm income volatility. Our analysis shows that the availability of fixed milk price contracts varies between milk processors. The statistical analysis shows that the adoption of these contracts is positively associated to the profitability and size of the farm. In addition, the analysis suggests that the impact of fixed milk price contract adoption on farm income is relatively small with a number of potential explanations requiring further research. We conclude that Irish dairy farmers require a toolbox of risk management tools, as multiple risk management tools are required in the management of income variability.

Keywords: Income volatility, dairy farming, risk management, fixed milk price contracts

JEL Classification: I31, J31, Q12

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1. Introduction

Dairy farming in Ireland has undergone a remarkable level of expansion. The abolition of the EU milk quota system in April 2015 has contributed towards rising milk production in Ireland (Läpple and SIRR 2019; Läpple et al 2020). At the same time, Irish dairy farmers are facing increasing uncertainty and risk with respect to their farm incomes where risk is imperfect knowledge about the known probabilities of possible outcomes and uncertainty is imperfect knowledge about unknown probabilities (Hardaker et al 2004). The increase in income uncertainty can be largely attributed to weather variability, policy reforms at the EU level, trade tensions, and a rise in the price volatility of global dairy commodity markets (Trestini and Chinchio 2018). In recent years, Brexit contributed to further increasing uncertainty in farm incomes (Donnellan and Hanrahan 2016; Lawless and Morgenroth 2019).

National governments have sought to further reduce the provision of ad hoc measures to cover catastrophic risks, because of the unpredictable nature of the costs and the growing budget constraints at the EU level (Severini et al 2018). EU regulations in relation to the granting of agricultural state aid have undergone significant revisions (European Union 2017). The onset of the Coronavirus pandemic prompted some further changes and extensions to state aid rules under the temporary state aid framework (European Union 2020). Cordier and Santerano (2019) outline the significance of the main revisions in 2017 including the introduction of grant subsidies for the establishment of mutual funds and the introduction of the so-called 'Income Stabilisation Tool'. The Income Stabilisation Tool (IST) is a risk management tool, which provides financial contributions to mutual funds in compensation to farmers in the event of a severe drop in their income (Tropea 2016). The IST is the subject of much research (see, for example, El Benni et al 2016; Trestini et al 2017; Severini et al 2019).

In Ireland, dairy processors have responded to the rise in milk price volatility by offering fixed milk price contracts to their farmer suppliers (Loughrey et al 2015; Loughrey et al 2018). In the United Kingdom, some milk processors have responded to the increased demand for risk management tools by offering similar contracts to their farmer suppliers (AHDB 2018; FWI 2019). Contractualisation has become an increasingly important feature of dairy supply chains in the United Kingdom as a response to market liberalisation and the rising price volatility (Thorsøe et al 2020). It is reported that fixed milk price contracts are not yet widespread among farmers in Germany (Hoehl and Hess 2021). However, dairy processors in Germany are increasingly offering voluntary schemes, which permit farmers to select a fixed milk price for the medium term (Peterson and Hess 2018).

As in the case of meat and crop producing farmers, dairy farmers must make their production decisions with a view to the future, including the purchase of cows, the leasing of land and hiring of additional labour. Large unexpected income fluctuations can influence the access to credit and the repayment of debt (Key et al 2017). Large income fluctuations can be particularly problematic during a period of significant milk production expansion and investment, as in the case of Irish dairy farming where raw milk production increased by approximately 45 per cent between 2012 and 2018 (Eurostat 2020). In modelling the investment decisions of dairy farmers in Germany, Schulte et al (2018) emphasise the importance of milk price volatility.

Elsewhere, Frick and Sauer (2020) identify a slowdown in technological change on dairy farms at the start of volatile market phases. The income instability experienced by dairy farmers can involve secondary effects and have negative implications for local rural economies (Vrolijk and Poppe 2008).

In this paper, we analyse the recent evolution of farm income volatility on Irish dairy farms between 1995 and 2018. This analysis is carried out so that we can identify the scale of the increase in price and income volatility. The analysis can provide a better understanding about the reasons for the increased demand for risk management tools. Furthermore, we examine the possible link between farm income volatility, the value of direct payments and the adoption of fixed milk price contracts. This provides us with some important insights about the potential for currently available risk management tools to address the problem of income volatility. At the same time, the results may highlight some limitations in these risk management tools and this can provide some lessons for the development of risk management tools in the future.

Significant consolidation of the dairy farming sector took place in Ireland during the study period. For instance, the total number of dairy herds declined from almost 50,000 in 1991 to less than 18,000 in 2014 with herd size increasing over time (Donnellan et al 2015). The total number of dairy herds includes both specialist and non-specialist dairy farms with specialist farms comprising of farms where dairy cows account for more than 75 per cent of grazing livestock (European Union 2008). The abolition of the milk quota system in April 2015 allowed farmers to expand production and new entrant farms to begin milk production. While this has provided individual farmers with the opportunity to expand, there are risks inherent in such expansion especially in the presence of highly volatile global dairy markets. In a study of Irish dairy farming, Läßle and Thorne (2019) conclude that farms with increased debt levels and expanding production are ‘particularly exposed to these volatile milk markets’.

In the next section, we provide some background about the topic of farm income volatility in Ireland. In section 3, we describe the data utilised in this study. In section 4, we provide a statistical analysis of price and income volatility. This is followed by a description of risk management tools. We describe the role of direct payments in reducing income volatility. We compare adopters and non-adopters of fixed milk price contracts in terms of their economic outcomes. This is followed finally by some conclusions and recommendations for future research.

2. Background

It is now widely accepted that the significant increase in the level of price volatility experienced by the Irish agri-food sector in recent years is expected to persist, and perhaps even increase, as EU policy continues to become more market focused and EU agri-food prices become more and more aligned with international prices (Blanco 2018). Price variation, to some degree, is both desirable and inevitable in all free markets, as it reflects the changing needs and preferences of customers and the changing cost and competitive positions of participants at all stages in the supply chain. However, the emergence of exceptional price volatility in dairy and

other food commodity markets in recent years is creating many problems for processors, farmers and other supply chain participants (O'Connor et al 2015).

The specific challenges which price/income volatility presents are numerous. High levels of volatility can negatively impact investment, while reduced certainty about cashflow can impair planning and restrict access to capital. Extreme volatility can inhibit research and development, and innovation, while the adoption of appropriate tools and solutions will enhance economic sustainability and competitiveness. Finally, an industry which manages volatility will be more sustainable, as it will be less prone to stop-start development. In a highly cyclical, capital-intensive, industry, it is most desirable to smooth out the milk intake pattern and not reduce capacity in the short term and have to rebuild it at a later time (Heinschink et al 2012, p. 9).

There are a number of reasons to suggest that Ireland may be more exposed to dairy price risk (in terms of both output and input prices) than other EU countries. First, the highly seasonal nature of milk production in Ireland can magnify the effect of short term international dairy product price changes. This seasonality, compounded with a product portfolio centred around commodity products (which compete solely on the basis of price) rather than value added products (where unique attributes would be more important), contributes to price exposure.

Second, the sector has a high dependence on third country markets, which are subject to greater volatility than the more mature EU markets. Third, the sector has an exposure to currency fluctuation, given the importance of the UK (sterling) and the international (dollar) trade. The volatility of the Euro-Sterling exchange rate is apparent since the Brexit referendum (Matthews 2017). Fourth, the grass based nature of Irish milk production, which is conditioned by local weather variations more than a grain based system, is another factor that is quite specific to milk production in Ireland. Finally, the anticipated continued expansion now that the EU milk quota has been removed, will increase farm specialisation and thus price and income risk, while increasing working capital and finance commitments, along with accentuating the previously mentioned factors.

The increase in volatility since 2007/2008 translates into increased risk for all participants in Irish dairy farming. The identification and adoption of suitable risk management tools will help to ensure that the agri-food sector remains competitive and profitable in an uncertain future. Thus, the consequences and management of price volatility is now a central issue for both the dairy industry itself and public policy. In this paper, we therefore explore the possible association between direct payments and fixed milk price contracts with income volatility.

3. Data

In this section, we describe the main data sources used to perform the analysis. These data are based on the Teagasc National Farm Survey (NFS) and the Central Statistics Office (CSO) monthly milk statistics survey.

The Teagasc (NFS) data are annually used to determine the broader financial situation on Irish farms and contribute to economic, rural development research and policy analysis. These data include the level of gross output, production costs, income and investment across the spectrum

of farming systems and farm sizes. These data form the Irish component of the Farm Accountancy Data Network (FADN) database, which is used to inform the European Commission on the status of farm incomes and the impacts of the Common Agricultural Policy.

In the Teagasc NFS, a farm accounts book is recorded for each year for a nationally representative survey of farms throughout Ireland, selected on the basis of a stratified random sample using information provided by the Central Statistics Office. In order to describe the extent of dairy farm income volatility over time, we establish an unbalanced panel dataset based on the Teagasc NFS micro data from 1995 to 2018.

In the Teagasc NFS, as farms exit new replacement farms are introduced to maintain the national farm population representativity of the sample for all farm systems and farm sizes (dairy and non-dairy). Therefore the panel is unbalanced, in the sense that there is some attrition from year to year, as farms leave the sample and are replaced by other farms. However, the attrition rate is relatively low and a sizeable proportion of the farms are contained in the dataset for all of the years analysed in this paper. For 2018, there are 309 specialist dairy farms included in the data, representing 16,165 specialist dairy farms nationally.

In table 1, we illustrate some summary statistics for key variables included in this research. Giving each farm observation equal weight, the average price for creamery milk was 30.4 cent per litre between 1996 and 2018 with a standard deviation of 4.3 cent per litre. From 1995 to 2018, the average family farm income was approximately €41,175 with a standard deviation of €37,307. From 2006 to 2018, the average Basic Payment was €16,447 with a standard deviation of €11,253. In section 5, we describe the importance of farm subsidies to dairy farmers in Ireland including the introduction of the dairy premium between 2004 and 2006.

Teagasc NFS data on milk sales is available from 1996 onwards. For the period from 1996 to 2018, the average volume of creamery milk sales was approximately 236,544 litres per farm with a standard deviation of 147,546. The total national volume of milk production was limited under the milk quota policy. Milk production increased substantially in the aftermath of quota abolition in April 2015, which we explore further in the next section. The average volume of creamery milk sales was therefore much higher between 2015 and 2018 relative to the period from 1996 to 2014. The average volume of creamery milk sales was approximately 378,310 litres from 2015 to 2018 with a standard deviation of 243,986.

The increase in creamery milk production and sales can be attributed to the rising number of dairy cows and the increase in yield per cow. Table 1 shows that the average herd size was approximately 48.5 dairy cows between 1996 and 2014. This compares with an average of 75.3 from 2015 to 2018 in the immediate aftermath of quota abolition.

In addition, we utilise data from the CSO monthly milk statistics survey to show the evolution of milk prices and production over time. The CSO monthly milk statistics are a census of all creameries and pasteurisers in Ireland. The main purpose of this survey is to provide information on the amount of cow's milk processed by dairy processors, which in turn gives an indication about the amount of milk being produced by Irish farmers. The survey includes variables in relation to milk intake, fat content, milk sold, cheese and butter. The CSO monthly

milk statistics are submitted to Eurostat so that comparisons can be made with milk statistics in other EU member states.

Table 1: Summary Statistics for Key Variables

Variable	Time Period	Unit of Analysis	Mean	Standard Deviation
Milk Price	1996-2018	Cent Per Litre	30.4	4.3
Family Farm Income	1995-2018	Euro (€)	41,175	37,307
Basic Payment	2006-2018	Euro (€)	16,447	11,253
Milk Volume				
Creamery Milk Sales	1996-2018	Litres	236,544	177,712
Creamery Milk Sales	1996-2014	Litres	209,698	147,546
Creamery Milk Sales	2015-2018	Litres	378,310	243,986
Herd Size				
No. of Dairy Cows	1996-2018	Cows	52.7	34.9
No. of Dairy Cows	1996-2014	Cows	48.5	31.2
No. of Dairy Cows	2015-2018	Cows	75.3	43.7
Sample Size (N)	1995-2018	Farms	301	

Source: Authors' calculations using the Teagasc National Farm Survey data

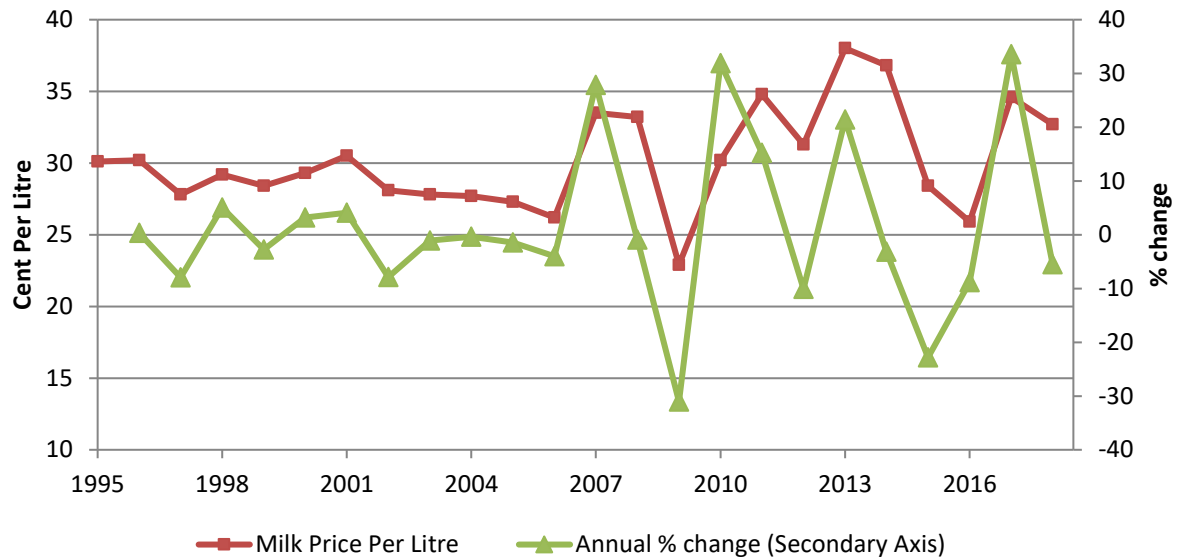
4. Price and Income Volatility Over Time

The increased level of milk price volatility faced by Irish dairy farmers is presented in Figure 1. From the mid-1990s to 2006, annual producer milk prices (for standardised milk) in Ireland fluctuated within a relatively narrow range of 26 to 30 cent per litre.² From 2006, this range has increased dramatically with a low of 23 cent per litre in 2009 and a high of 38 cent per litre in 2013. This volatility is more striking when we consider the annual percentage change (measured on the secondary y-axis). Annual changes of in excess of 30 per cent have occurred in recent times, while an annual change in excess of 10 per cent was unprecedented prior to 2007.

Bergmann et al (2015) show that the increase in the volatility of milk prices is evident at the EU level. Jongeneel and van Berkum (2015, p. 8) conclude that the increase in price volatility is a response to the 'transformation of the classical price support regime of the CAP into a safety net provision, which only protects farmers against extreme downside price risks'. Müller et al (2018) find that the volatility of Irish milk prices exceeded the volatility in most other EU member states over the period from 2001 to 2015.

² Standardised price means that actual milk prices are adjusted to 3.7% fat and 3.3% protein content.

Figure 1: Standardised Manufacturing Milk Price and Percentage Change 1995-2018



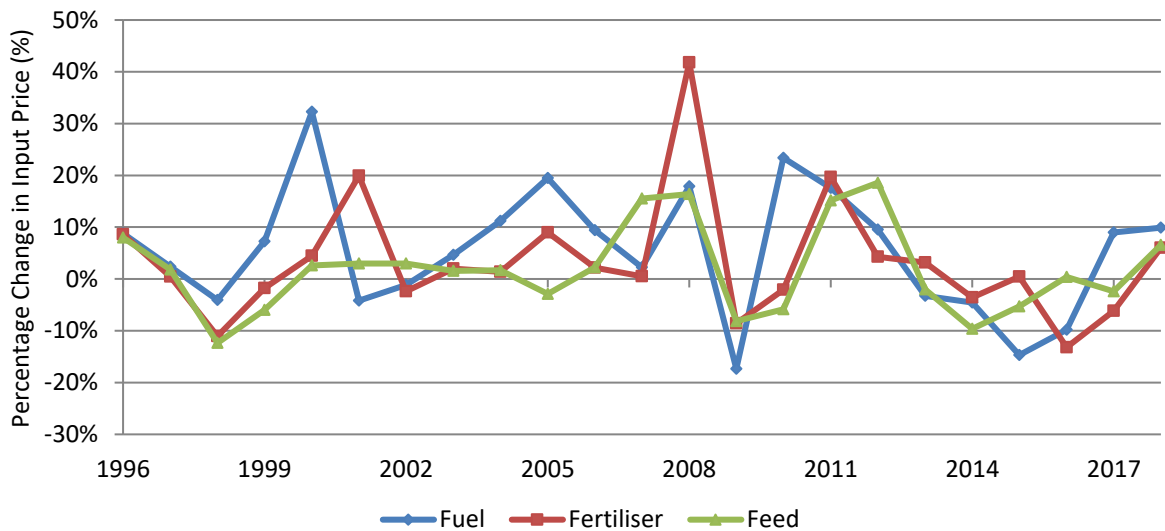
Source: CSO with Author's calculations for the annual percentage change

Irish dairy farmers have contended with volatile input prices. Figure 2 shows that nominal fuel and fertilizer prices increased dramatically post 2007 (due to the upward surge in oil and other energy prices) and are far more volatile than prior to 2007. Taylor et al (2018) identified significant volatility in the price of the main inputs for beef farming systems in Ireland between 2008 and 2014. Crosson et al (2006) discussed the volatility of input prices for beef producers in Ireland and the important role of cereal prices in affecting the volatility of feed prices. These feed costs are also very important for dairy farmers as concentrate feed tends to account for a significant share of overall costs with significant influences on economic performance (O'Brien et al 2015).

Figure 2 also shows that fuel, feed and fertiliser prices can sometimes move in the same direction with large price increases evident for all of these inputs in 2008 and 2011. Significant price declines occurred for all of these inputs in 1998 and 2009. Significant co-movement in input prices has the potential to affect the extent of farm income volatility in a given year.

Adverse weather can also impact on feed volumes with further implications for farm performance as was the case in 2018 (Dillon *et al.*, 2018, p. 3). Adverse weather can lead to a sharp decline in feed availability, which can further contribute to rising input prices in the short-term. Hired labour costs and land rental costs may in some instances account for a large share of total farm costs, but the prices for these inputs tend to be less volatile over time.

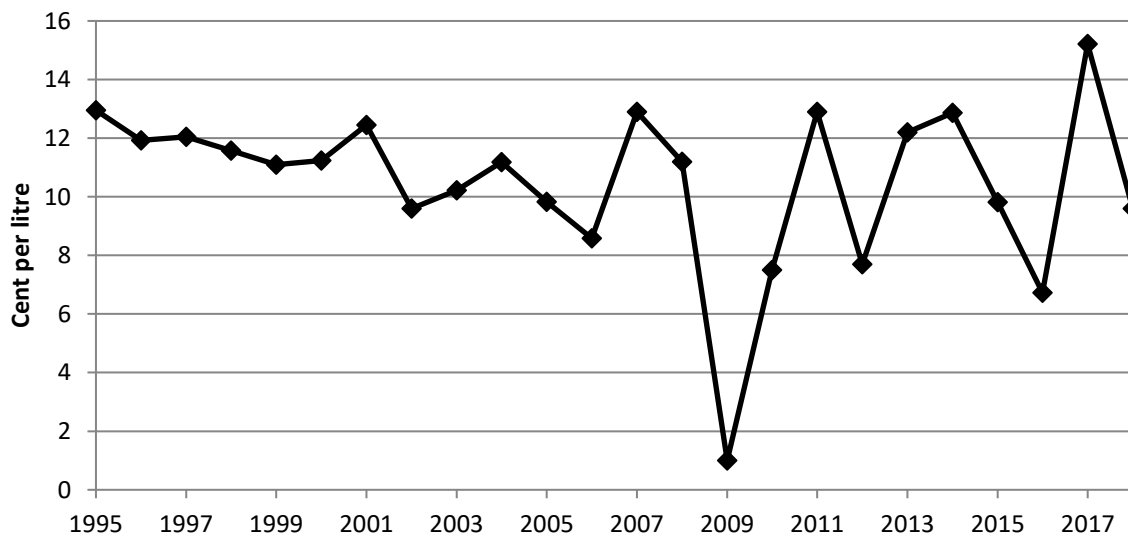
Figure 2: Annual Percentage Change in Agricultural Input Prices 1996-2018



Source: Authors calculations based on CSO data

When both volatile input and output prices are combined with other costs, we can see that the average net margin per litre for milk production in Ireland displays greatly increased volatility from 2007 onwards, as observed in Figure 3.

Figure 3: Average Annual Net Margin per litre on Specialist Dairy Farms in Ireland 1995 to 2018



Source: Donnellan et al 2015 and updated with Teagasc Dairy Factsheets (Teagasc 2017; Teagasc 2019)

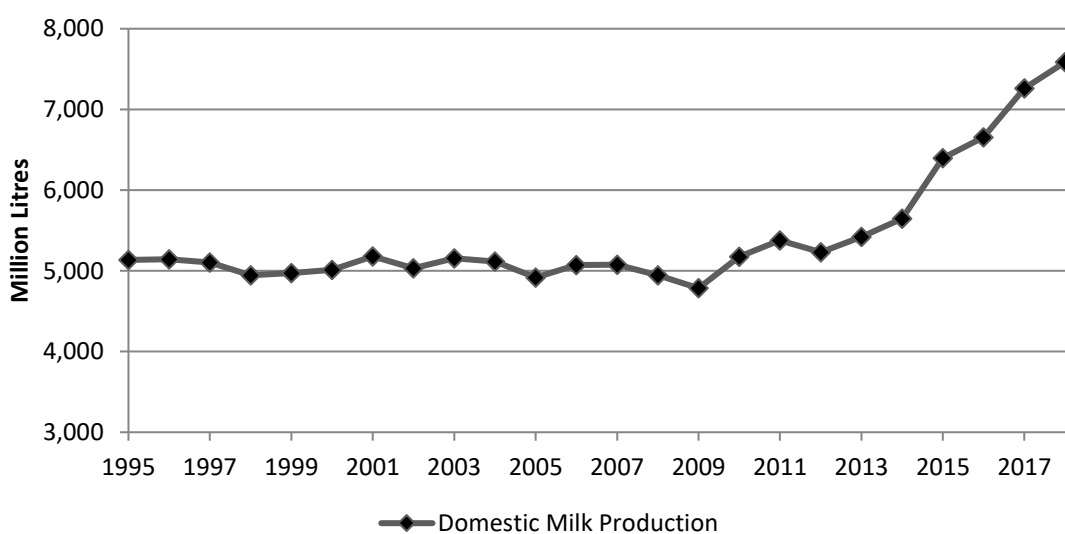
The increase in the volatility in the net margin per litre of milk from 2007 onwards predates the remarkable increase in milk production in subsequent years. Quota abolition has offered farmers the opportunity to expand their production, but these two developments contribute to an increasingly risky environment for Irish dairy farmers.

The intention to abolish milk quota was announced in November 2008 under the CAP ‘Health Check’ with plans to abolish quota completely by 2015. The European Commission permitted a gradual increase in milk quota for each member state of 2% in 2008, and a further 1% per annum thereafter (IPTS, 2009). This facilitated an increase in milk production in Ireland and other EU member states between 2009 and 2015 (Eurostat 2020). As part of this gradual expansion in milk production, the Irish government approved the allocation of additional milk quota to a small number of new entrants to dairy production (McDonald et al 2013). The extension services provided an important support to dairy farms in adjusting to the new policy environment in terms of dairy herd expansion, intensification and specialisation (Läpple et al 2020).

Figure 4 shows that the increase in overall milk production is largely confined to the period since 2012. Figure 4 shows that the increase in production is particularly evident in 2015 as quota was abolished. Milk production grew at a slower rate in 2016 as a result of poor milk prices but recovered strongly in 2017 as milk prices reached particularly high levels. In comparison to Ireland, the post-quota increase in total milk production has followed a slower rate in other EU member states. In the Netherlands, the total milk production actually declined in 2018 as a result of environmental constraints and the introduction of a phosphate trading scheme (AHDB 2019; Eurostat 2020). In recent years, milk production has tended to expand in countries with a comparative advantage in terms of the availability of pasture land (Ramsbottom et al 2020).

The rise in Irish milk production is greater if expressed in terms of fat and protein solid content. Kelly et al (2020) show that total milk fat and protein production increased by 64 per cent between the average for the period 2007-2009 and 2018 while total milk production increased by 54 per cent during the same time.

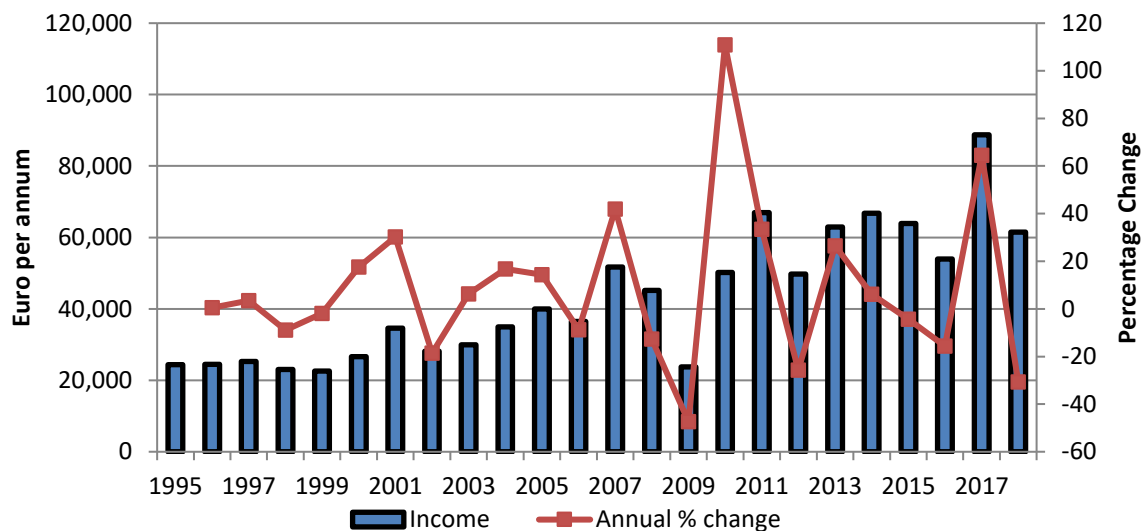
Figure 4: Domestic Milk Production 1995-2018 (Million Litres)



Source: CSO (2019)

The pattern of volatility in farm net margin revealed in Figure 3 (which excludes support payments) is also reflected in the average family farm income on specialist dairy farms (which includes support payments) in Figure 5. In recent years, there are examples where income has almost halved (2009) in one year. The large fall in income in 2009 can be explained by a milk price crash in a period of elevated input prices. Vrolijk and Poppe (2020) find a similarly large decline in dairy farm incomes in 2009 in the Netherlands. The decline in 2016 is somewhat different and is influenced by the strong incomes in 2013 and 2014, but also reflects the relatively low milk price in 2016, associated with low dairy commodity prices. Farm income recovered strongly in 2017 with rising milk prices. Annual changes in average dairy farm income, as measured by the Teagasc NFS of plus or minus 30 per cent are now common and can be attributed to adverse changes in output prices or inputs costs as was the case in 2018 with very difficult weather conditions. The percentage change in farm income in 1995 is not reported due to the non-availability of farm income data for 1994.

Figure 5: Average Family Farm Income on Specialist Dairy Farms 1995 to 2018

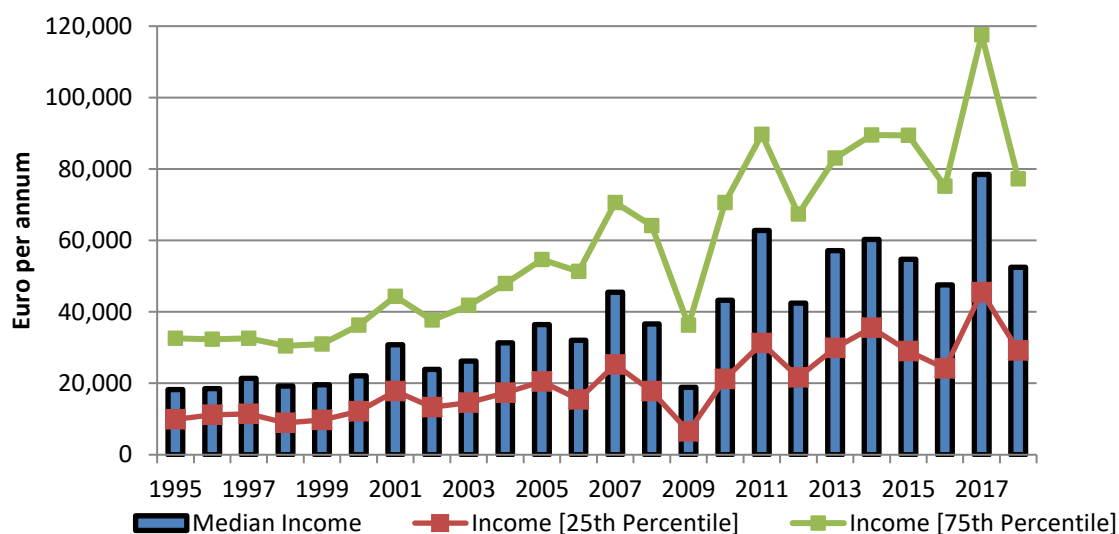


Source: Teagasc National Farm Survey

In Figure 6, we show the interquartile range of family farm incomes and the evolution through time. Figure 6 reveals the high degree of variability or dispersion in farm income between farms. For much of the period, the farm income of the 75th percentile is approximately three times higher than the farm income of the 25th percentile. In absolute nominal terms, the interquartile range has grown through time. For instance, the interquartile range was approximately €70,000 in 2017 in comparison to approximately €26,000 in 2001. This trend points towards a substantial increase in absolute income inequality over time. The information contained in Figure 6 indicates the extent of income inequality, but does not provide insight into the issue of relative income mobility³. In addition, there is no adjustment for any change over time in the number of family (unpaid) labour units that are supported by this income.

³ Relative income mobility is concerned with the extent to which individuals change places in the income distribution (Hungerford 2008).

Figure 6: Family Farm Income on Specialist Dairy Farms 1995 to 2018



Source: Teagasc National Farm Survey

Farmers are chiefly concerned with downside risks (Chavas and Shi 2015; Chavas 2019). We therefore describe the prevalence of large drops in farm income over time. The Green Box criteria of the World Trade Organisation (WTO) outlines the eligibility criteria for government financial participation in income insurance and income safety-net programmes. These criteria permits payments in circumstances where the income losses exceed 30 per cent relative to income in a specific reference period (WTO, 1999, p. 50).

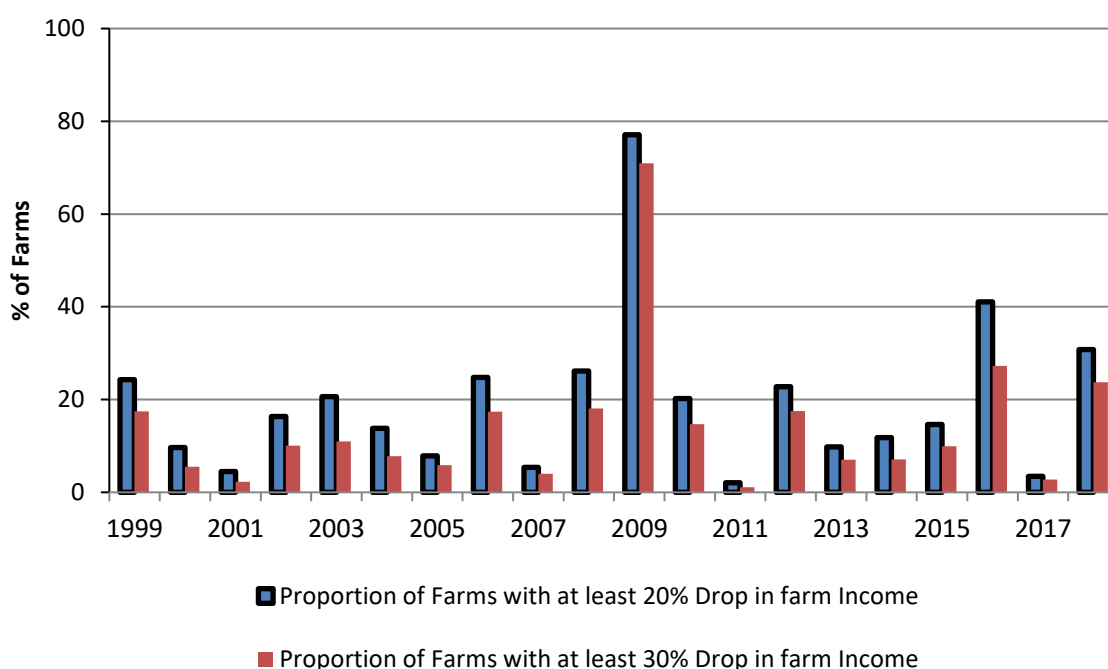
The specific reference period for measuring the income drops is the average income of the three preceding years. This means that the percentage drop in income is based on the income change relative to the average income of the three preceding years. The European Commission has broadened the criteria for defining the reference period and the detail of this amendment is outlined in Regulation (EU) 2017/2393. Under this regulation, the reference period can also be established using a three-year average based on the preceding five-year period excluding the highest and lowest entries. For practical reasons, we describe the incidence of large income drops using the average income of the preceding three years. The European Commission have used this indicator to show that at least 20 per cent of farmers in the EU-25 experience an income loss larger than 30 per cent in most years. The Commission reports that across the EU, specialist dairy farmers in 2009 experienced the highest income drop, with 50 per cent in the EU-25 having an income loss of at least 30 per cent (European Commission, 2017).

In Figure 7, we show the proportion of dairy farms with at least a 30 per cent drop in farm income in each year relative to the reference period. Due to the revised EU regulations in relation to the granting of agricultural state aid, we also include the proportion of farms experiencing a loss of at least 20 per cent. Matthews (2018) explains that the thresholds can be lowered to 20 per cent for individual sectors. Figure 7 shows that in our sample of dairy farmers from the Teagasc NFS, the percentage of farms with a 30 per cent income drop is highest in

2009, when approximately 70 per cent of dairy farms experienced a drop of at least this magnitude.

Figure 7 shows that the percentage of farms with at least a 20 per cent income drop was slightly higher in 2009 relative to the proportion experiencing a drop of at least 30 per cent. In most years, the choice of threshold does not appear to impact the results. Recent exceptions include however, both 2016 and 2018. In 2016, the proportion of farms with at least a 20 per cent income drop was almost 40 per cent while the proportion of farms with at least a 30 per cent drop was approximately 26 per cent. These large falls in income are largely attributable to relatively poor milk prices. In 2018, the proportion of farms with at least a 20 per cent income drop was almost 31 per cent while the proportion of farms with at least a 30 per cent drop was approximately 24 per cent. In 2018, the large falls in income can be largely attributed to the negative impact of the summer drought and the consequent rise in feed input expenditures.

Figure 7: Percentage of Farms with Large Drops in Farm Income 1999-2018



Source: Authors' Calculations Based on Teagasc National Farm Survey data 1997-2018

5. Risk Management Tools

In this section, we describe two risk management tools, which are currently available to farmers in Ireland; i.e. the EU direct payments and fixed milk price contracts. This allows us to establish a better understanding about the effectiveness of these tools in addressing income volatility.

Direct Payments

Historically, milk production in the EU did not benefit from significant direct payment support. Instead, specific support for milk production was provided through a range of market management mechanism, including the milk quota system and market price support via the

butter and skimmed milk powder intervention mechanisms. A range of import tariffs and export refunds ensured that EU domestic prices for dairy products remained above the world price level (Jongeneel et al 2010; Donnellan et al 2015). To facilitate greater integration with world agricultural markets, the EU suspended the use of export refunds. However, in order to do this, it first made downward adjustments to intervention prices for butter and skimmed milk powder as part of the CAP Reform of 2003. In return, the EU provided dairy farmers with compensation for these intervention price reductions via the dairy premium (Rude 2008).

However, the dairy premium was not the only form of CAP support available to dairy farmers in Ireland. Many dairy farmers also had another farm enterprise (generally drystock) and this activity also benefitted from EU support payments. When the decoupling of EU support payments was introduced in 2005, the relatively modest support for dairy intervention price reductions and the more substantial support available for other enterprises on dairy farms were combined to form a decoupled direct payment to milk producers in the EU. Under the terms of the decoupled payment, EU dairy producers were free to operate whichever farm enterprise they chose, with the exception of dairy. Their capacity to produce milk remained constrained by the amount of milk quota in their possession.

Under the current direct payment system, a farmer's payment can be a combination of payment under four separate schemes (DAFM, 2018).

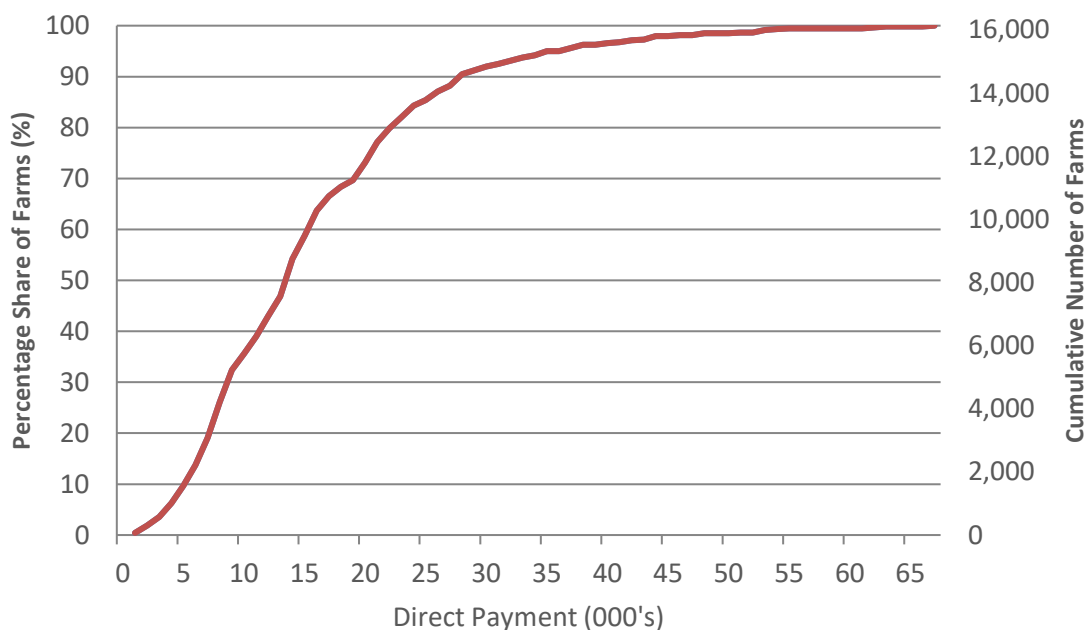
- Basic Payment Scheme (BPS)
- Payment for Agricultural Practices beneficial for the Climate and the Environment (Greening Payment)
- Young Farmers Scheme (YFS)
- Aid for Protein Crops

The ending of the milk quota system in 2015 has allowed dairy farmers to move towards complete specialisation in milk production, without impacting on the value of the support received. With another round of CAP reform now under negotiation, it is useful to examine the current role of support payments in addressing income volatility. Knapp and Loughrey (2017) identified a positive relationship between the value of farm subsidies and the extent of market income volatility (farm profit exclusive of support payments) on drystock farms during the period from 2005 to 2013. However, in the same analysis, it was found among dairy farmers, that no statistically significant relationship could be identified between the amount of support payments and market income volatility. This suggests that farm subsidies play a limited role in influencing market income volatility on dairy farms as the share of income represented by support payments is low relative to other farming sectors. Dairy farms are also in receipt of other support payments, which are not part of the direct payment including GLAS payments⁴ and payments from the Rural Environmental Protection Scheme (REPS). In the case of dairy, generally the value of these other payments is small relative to the value of the direct payment.

⁴ GLAS stands for the Green Low Carbon Agri-Environment Scheme

In Figure 8, we illustrate the size and distribution of the direct payments for specialist dairy farms in Ireland for 2018. Figure 8 shows that the vast majority of specialist dairy farms received a payment between €5,000 and €20,000 per annum. Approximately one third of specialist dairy farms received a direct payment less than €10,000 per annum. Approximately 10 per cent of the specialist dairy farms received a direct payment in excess of €30,000 per annum. Overall, it appears that there is significant variability between farms in terms of the value of the direct payments received. This suggests that the capacity of direct payments to reduce income volatility varies significantly between farms.

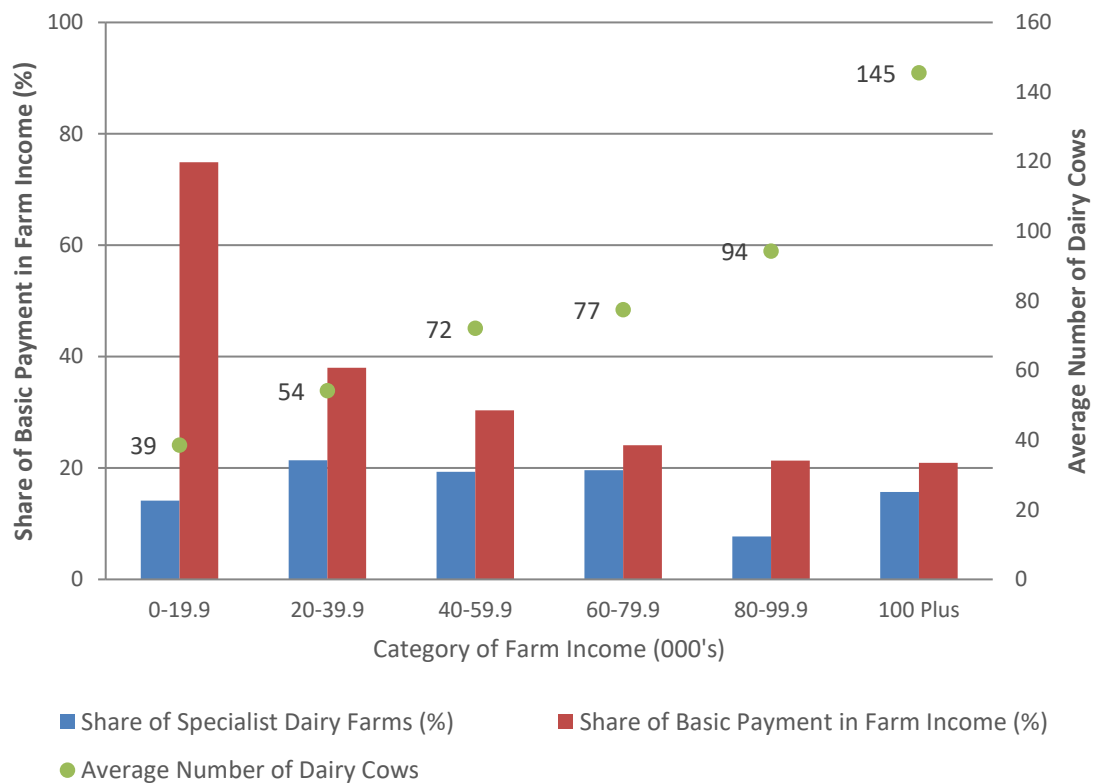
Figure 8: Size and Distribution of Direct Payments in 2018



Source: Teagasc National Farm Survey 2018

This conclusion is supported by evidence that the share of basic payments in farm income tends to vary with farm income. Using Teagasc NFS data, Figure 9 shows that the share of basic payments in farm income is notably high for the lowest categories of farm income i.e. where the farm income is below €40,000 per annum. For the lowest farm income category, the share of basic payments in farm income is approximately 75 per cent. The average share of basic payments in farm income is approximately 20 to 25 per cent for categories of farm income above €60,000 per annum. Basic payments therefore play an important role in reducing income volatility across the distribution but the relative importance of these payments appears much greater for dairy farms in the bottom and middle relative to the top of the farm income distribution. In addition, we can note from Figure 9 that the average number of dairy cows is much larger on farms in the highest income category relative to farms in categories with less farm income.

Figure 9: Share of Basic Payments in Farm Income for Specialist Dairy Farms in 2018



Source: Author’s Calculations using Teagasc National Farm Survey Data

Impact of Direct Payments on Income Volatility

In the following, we examine the association between the value of direct payments and the volatility of family farm income. To estimate the degree of farm income volatility at the farm level, we calculate the *Absolute Arc Percentage* change in farm income. In calculating the Absolute Arc percentage change, we express the change in family farm income relative to the average of two base years i.e. the average of the income from the current and previous year.

The Absolute Arc percentage change therefore differs from the standard year-on-year percentage change. The Absolute Arc percentage change is considered to be a useful way of avoiding extreme percentage changes in income. Extreme values can emerge with a reliance on a single base year for the calculation. The Absolute Arc percentage change is a method to represent the directionless extent of the income changes over time. The formula for the Absolute Arc percentage change is outlined in the Appendix. This approach was applied in a recent US Department of Agriculture study on farm income risk in the United States (Key et al 2017, p. 8).

In Figures 10-12, we show the median Absolute Arc percentage change in farm income for three income groups. These three income groups are 1) middle third of farm income 2) top third of farm income 3) bottom third of farm income. Figure 10 suggests that income volatility for middle income dairy farmers was particularly high in 2009, 2010 and 2017. Figures 11 and 12 suggest a similar pattern for dairy farmers at the top and bottom of the farm income distribution.

The results suggest that farm income volatility tends to be highest for farms in the bottom one third of the dairy farm income distribution. To some extent, this reflects the choice of methodology. In Figure 13, we provide additional information to indicate a possible role for input costs in influencing the income volatility on farms in the bottom of the distribution.

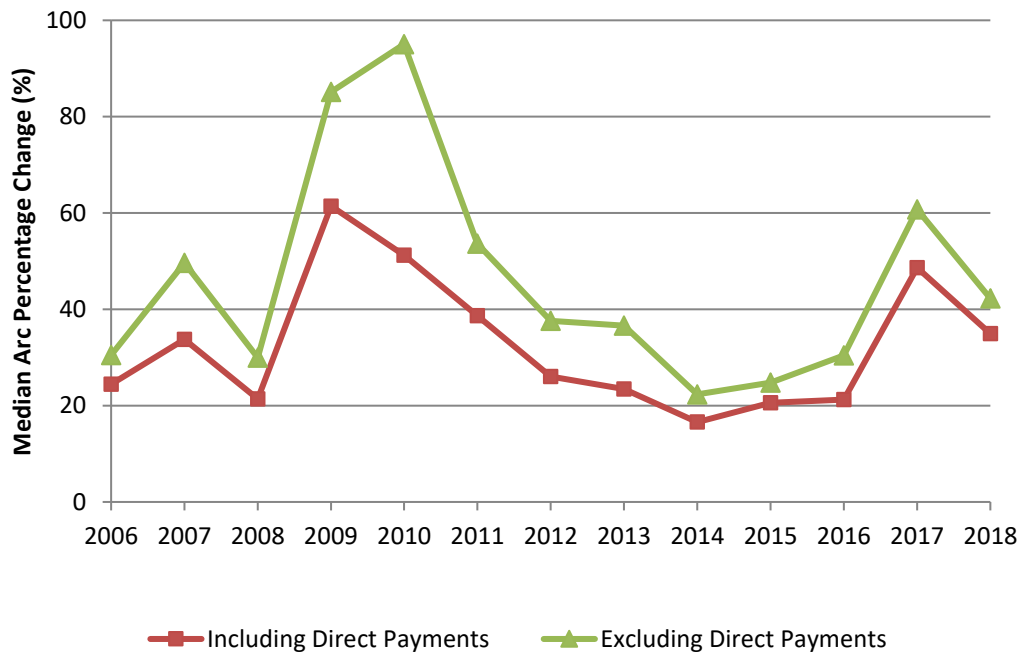
In Figure 11, it seems that the absolute arc percentage change is quite similar for with and without direct payments. This implies that direct payments play a lesser role in mitigating income volatility on higher income farms relative to farms, which are lower in the farm income distribution. For farms in the higher end of the dairy farm income distribution, the volatility in market prices play a more important role in influencing overall income volatility. In Figure 12, it is evident that direct payments play a major role in reducing farm income volatility for farms located in the bottom one third of the dairy farm income distribution. For instance, the median absolute arc percentage change in income was approximately 60 per cent in 2009 for the bottom one third of the distribution. In the absence of direct payments, the median absolute arc percentage change would have been 108 per cent in 2009. Interestingly, it appears that the bottom one third of the distribution coped much better with the 2016 milk price crisis relative to the crisis in 2009, which involved extremely low output prices and elevated input prices.

Direct payments are likely to change significantly under the next CAP reform. In June 2018, the European Commission published a set of legislative proposals based on the intended simplification and modernisation of the CAP. Matthews (2018) describes the possible implications of these proposals for the size and distribution of direct payments including ‘the redistribution of support from bigger to smaller and medium-sized farms’. Dairy farms in Ireland are relatively larger in size than non-dairy cattle farms (Dillon et al 2019). Future CAP reforms could therefore have some effect on the size of direct payments received with potential implications for income volatility. At a global level, Matthews (2020) goes further to conclude that the next CAP reform should be better aligned with the UN Sustainable Development Goals (SDGs) with measurable, time-bound targets linked to the SDGs.

Dairy farmers will face some challenges as policies change in line with the European Union Green Deal (European Commission 2019). The EU Green Deal is in line with the commitment of the European Union to adhere to the Paris Agreement on climate change (UNFCCC 2016). Under the next CAP reform, the direct payments are likely to have enhanced conditionality as described in (Guyomard, Bureau et al. 2020). In general, it appears that environmental constraints and regulations will be increasingly important in the overall risk management of dairy farms. The EU Green Deal stipulates that the next CAP will devote at least 40% of the overall budget to climate action.

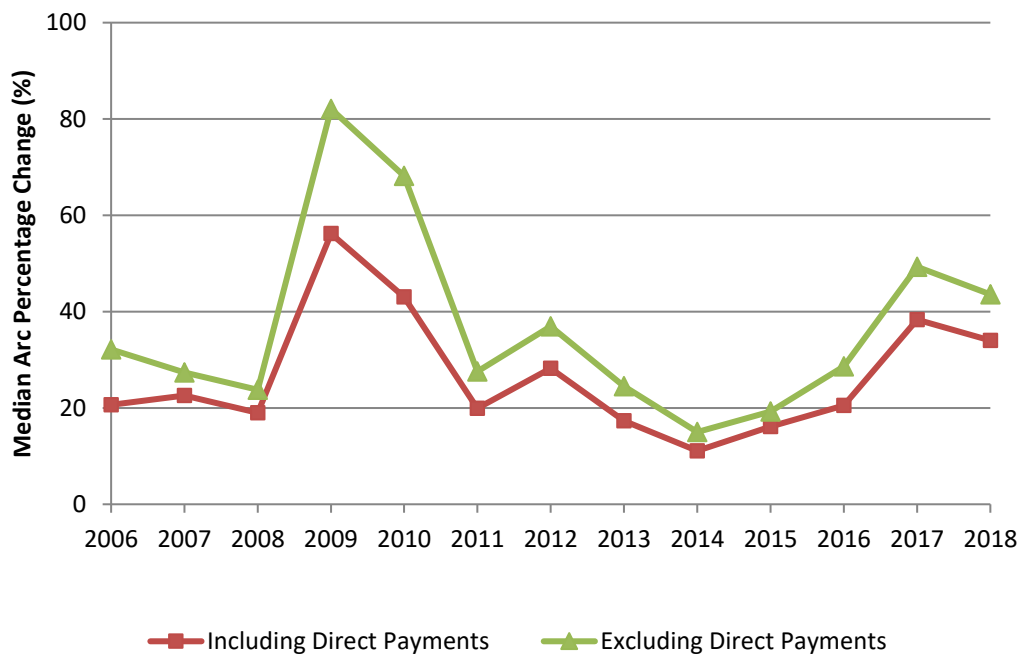
Among the potential new policies are the eco-schemes. The introduction of eco-schemes can incentivise farmers to change agricultural practices, which are concerned with the environment. These payments could replace a proportion of the direct payments. Under the eco-schemes, farmers would voluntarily apply each year to receive support in the form of payments per hectare (Poppe and Koutstaal 2020). As direct payments provide a buffer to many farmers, the increased conditionality of payments will be an important consideration in farm-level risk management.

Figure 10: Absolute Arc Percentage Change in Family Farm Income (Middle Income Farmers)



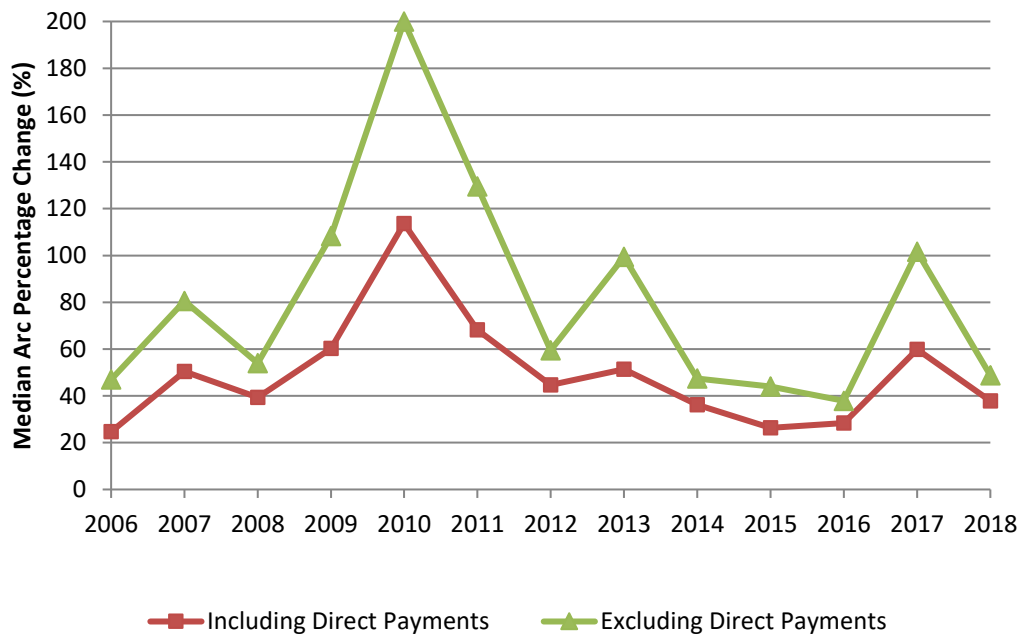
Source: Authors' calculations using the Teagasc National Farm Survey data

Figure 11: Absolute Arc Percentage Change in Family Farm Income (Top Income Farmers)



Source: Authors' calculations using the Teagasc National Farm Survey data

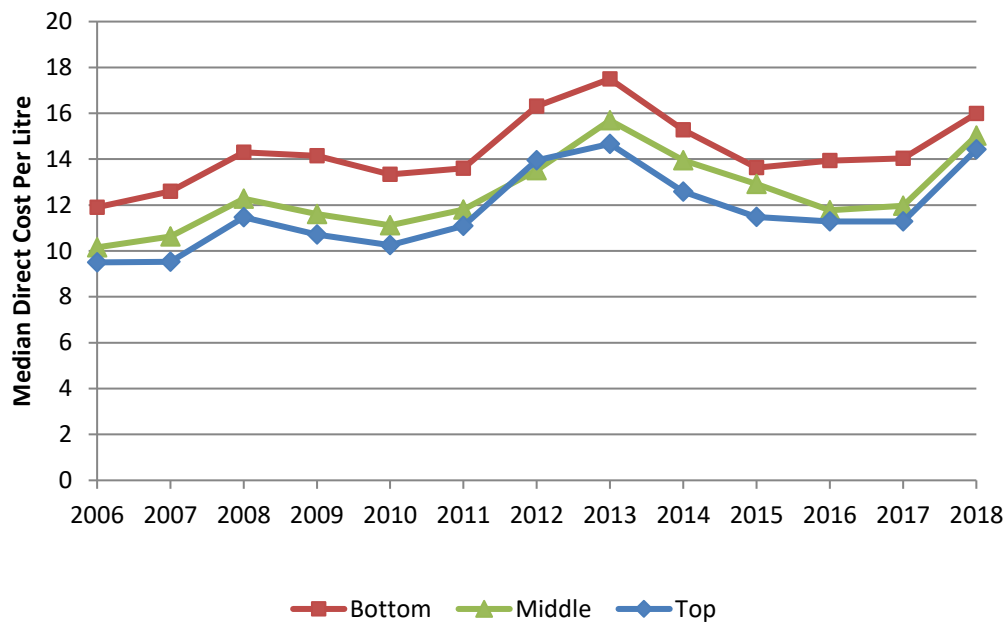
Figure 12: Absolute Arc Percentage Change in Family Farm Income (Bottom Income Farmers)



Source: Authors' calculations using the Teagasc National Farm Survey data

Figure 13 shows that there are differences between the top and bottom income farmers in terms of the direct costs per unit of production. In most years, there are only small differences between the top and middle of the distribution in terms of the direct costs per litre. Further analysis suggests that the average annual milk price tends to vary only slightly between the top, middle and bottom groups. These small differences may be due to differences in fat and protein content, the choice of processor or the inclusion of bonuses or penalties. Other things equal, the smaller implicit net margin implied by Figure 13 means that greater income volatility on farms in the bottom income group occurs in the face of a similar variation in either milk or input prices. For the bottom income group in particular, the influence of input prices on income volatility is likely to be particularly acute when there is co-movement in the price of essential inputs such as fuel, feed and fertiliser.

Figure 13: Median Direct Costs Per Litre (Top, Middle and Bottom Income Farmers)



Source: Authors' calculations using the Teagasc National Farm Survey data

Fixed Milk Price Contracts

The practice of forward contracting of the price paid to farmers for their output is more closely associated with grain than milk production and this is reflected in the economic literature (for example, Asplund et al 1989; Coffey and Schroeder 2019). Among the few studies of milk forward contract adoption, Wolf and Widmar (2014) have found a positive association between milk forward contract adoption and the herd size and education level of the farm operator. Loughrey et al (2015) examined the intentions of Irish dairy farmers towards the adoption of fixed milk price contracts and identified the recent milk price history as an important factor in influencing adoption intentions.

Elsewhere, Kuethe and Morehart (2014) used propensity score matching to assess the impact of risk management tool adoption on farm income in the United States. As with much of the recent literature, Kuethe and Morehart only dealt with the short term profit impact of tool adoption in three separate years. Kuethe and Morehart found that the adoption of output price risk management tools such as options and futures was associated with lower farm income. Kuethe and Morehart concluded that analysis that 'spans multiple years for the same operations would provide valuable information on both the profit and risk impacts of risk management tools'. However, due to data limitations, the economic literature on this topic has focused on the impact of adoption in the short-term (see, for example, Enjolras et al 2014). Due to the relative newness of fixed milk price contracts and the associated data limitations, we analyse the possible association between adoption and farm income in the short-term.

Fixed milk price contracts are a relatively new development in Irish dairy farming. Glanbia was the first of the Irish milk processors to announce a fixed price forward contract for Irish dairy farmers in late 2010, made available for milk delivered in 2011. This was closely monitored by other Irish milk processors and the Glanbia initiative was soon followed by the introduction of forward fixed milk price guarantees by other milk processors. The precise terms and conditions of forward contract offerings varies between processors. For this reason, we should not seek to make direct comparisons between milk processors in terms of the overall value of the fixed price contracts for farmers.

In table 2, we compare the milk processors in terms of the coverage of their milk price contract offerings between 2011 and 2017. We outline the initial starting date of the first fixed milk price contract offered by each milk processor.

A large proportion of Glanbia suppliers are located in two NUTS 3 regions (Mid-East and South-East). North Cork covers a small area in the South-West region, while Kerry group covers a large proportion of the South-West and Mid-West regions. Arrabawn, Aurivo, LacPatrick and Lakeland are the dominant processors in the Border, West, North-West, Mid-West and Midlands NUTS 3 regions and these processors introduced fixed price contracts somewhat later in 2016 and 2017. This suggests that there is a close connection between the availability of fixed milk price contracts and the processor collection area in which a farm is located.

The permitted maximum share of production varies between milk processors with Glanbia, Kerry, LacPatrick and Carbery permitting a maximum of 20 per cent of production in most or all of their contracts to date. The maximum share permitted in any one contract has tended to be lower for the cases of Arrabawn, Aurivo and Dairygold. There are significant differences in the number of contracts offered by each milk processor over time with Glanbia having nine active schemes during this time. Centenary Thurles has offered the same contract conditions as Glanbia since 2015. Most other processors offered one or two different contract offerings during the period up to the end of 2017. As farms may be participating in multiple fixed price contracts at any one time, there is the scope for some farms to allocate over one third of their production into fixed milk price contracts. This situation is plausible for farms supplying Glanbia where there is significant overlap in the timing of fixed milk price offerings.

Table 2: Details of Fixed Milk Price (FMP) Contracts by Milk Processor 2011-2017

	Time of First FMP Contract	Main NUTS3 Regional Area(s)	Maximum Share of Production in each contract	Number of Contracts Offered
Glanbia	Jan-11	Mid-East, South-East	20	9
North Cork	Jan-14	South-West	20	2
Kerry	Mar-15	South-West	20	1
Carbery Group	Apr-15	South-West	20	1
Centenary Thurles	Apr-15	Mid-West, South-East	20	7
Dairygold	Mar-16	South-West	15	2
Lakeland	Jun-16	Midlands, Border	10	1
Aurivo	Aug-16	West, North-West	10	2
LacPatrick	Jan-17	Border	20	1
Arrabawn	Mar-17	West and Mid-West	10	1

Sources: Various Sources including Irish Farmers Journal, Agriland.ie, Aurivo.ie, Glanbiaconnect.com, Drinagh.com, Northcorkcreameries.com, Dairygold annual reports and Independent.ie.

Association of Fixed Milk Price Contracts with Milk Price and Farm Income

One would expect that the adoption of fixed milk price contracts reduces farm income volatility over time. Data limitations prevent us from assessing the impact of adoption on price volatility and farm income volatility over the medium to long term. However, it is possible to assess the possible association between adoption and milk price in some recent years. We therefore explore the association between adoption, farm income and average milk price in 2016 and 2017. These two years are particularly important examples. The average milk price was particularly low in 2016 but recovered strongly to reach high levels in 2017 (See Figure 1).

Teagasc NFS data in relation to fixed milk price contracts is collected from farms in 2016 and 2017. For 2016, there are 324 specialist dairy farms included in the NFS data, representing 16,140 dairy farms nationally. However, the proportion of farms responding to the question on fixed milk price contracts is approximately 73 per cent. For 2016, we therefore utilise data from 237 specialist dairy farms in relation to fixed milk price contracts. The vast majority of farms who responded to the question of contract adoption in 2016 also responded to this question in 2017. However, there are a small number of farms who did not respond to the question in one of those years. We therefore present the results separately for each year. For 2017, we utilise data from 223 specialist dairy farms in relation to fixed milk price contracts.

As fixed milk price contracts are designed to reduce price volatility, one would therefore anticipate that the adopters of fixed milk price contracts received a higher milk price than the non-adopters in 2016. For instance, Glanbia offered, in their phase 7 scheme, a standardised fixed milk price of 29 cent per litre to their farmer suppliers for the period from April 2016 to

December 2018 (Glanbia 2016a). This was well above the standardised average milk price, which prevailed during 2016 (See Figure 1).

In addition, we anticipate that the adopters of fixed price contracts received a lower average milk price in 2017 relative to non-adopters. Glanbia offered a standardised fixed milk price of 31.75 cent per litre in their phase 9 fixed milk price scheme, which was available to their suppliers for all of 2017 (Glanbia 2016b). Most other processors offered fixed milk contracts during 2017 with some variation between contracts in terms of the fixed price. All of the relevant fixed prices were below the spot prices offered in 2017. We may therefore anticipate that the adoption of fixed milk prices reduced the average milk price received in 2017.

In Tables 3 and 4, we compare some summary statistics for two groups in both years 1) farms with no evidence of adopting fixed milk price contracts 2) farms which availed of a fixed milk price contract. The summary statistics are based on independent sample t-tests. The data are based on the farms, which provided information on the adoption of fixed milk price contracts in either 2016 or 2017.

Table 3 shows a positive and significant association between the adoption of fixed milk price contracts and average milk price in 2016, an expected result given the extremely low spot prices in that year. The average milk price for adopters was 27.76 cent per litre in comparison to 26.92 cent per litre for those farms, which did not adopt fixed milk price contracts in 2016. This involves a significant difference of 0.84 per cent per litre. The adopters of fixed milk price contracts appear to have benefitted from adoption in 2016 both in terms of achieving a better price in the short-term and reducing price volatility. This may be attributed to the level of fixed milk prices being significantly above the level of spot milk prices. The weighted average of specialist dairy farms in the NFS having forward sold their milk in 2016 was found to be 34 per cent of farmers. There is insufficient information available to provide a precise national-level estimate about the share of milk volume entered into fixed milk price contracts. However, the share of total national milk production entered into fixed milk price contracts is likely to be significantly less than 34 per cent.

In 2016, Family farm income appears significantly higher among adopters but only a minority of this difference can possibly be attributed to the adoption of fixed milk price contracts. Adopters have much higher milk production levels (422,523 litres) relative to non-adopters (331,033 litres). This suggests that the level of production could be an important factor in influencing the adoption of fixed milk price contracts.

In addition, the adoption of fixed milk price contracts was significantly higher in the eastern region, which comprises of the south-east and mid-east NUTS 3 regions. In 2016, we find that 62 per cent of the adopters of fixed milk price contracts were located in the Eastern region. By contrast, only 20 per cent of non-adopters were located on farms in the Eastern region. These results are probably explained by the large presence of Glanbia in the eastern region.

In addition, there were notable differences between both groups in terms of the share of direct payments in overall farm income with a median (28.87 per cent) for adopters versus (34.05 per cent) for non-adopters. This may suggest that adoption is influenced by the extent of reliance

on direct payments as a contributor to farm income. This potential relationship can be considered further in a study of adoption.

Table 3: Independent Sample T-Test Comparison of Adopters and Non-Adopters of FMP Contracts (2016)

	Non-Adopters	Adopters	Combined	Difference
Milk Price	26.92	27.76	27.23	0.84***
Family Farm Income [€]	45,771	65,414	52,904	19,643***
Annual Change in Family Farm Income [€]	-10,375	-9,858	-10,189	516
Basic Payment (€)	15,574	19,411	16,967	3,836**
Litres of Milk Sold to the Creamery East Region (0,1)	331,033	422,523	364,255	91,490***
Sample Size [N]	147	90	237	

Source: Authors' calculations using the Teagasc National Farm Survey data

Note: *** denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, * denotes statistical significance at the 10% level.

The results in Table 4 show a positive but insignificant association between the adoption of fixed milk price contracts and average milk price in 2017. The lack of a significant association is surprising given the relatively high milk prices, which prevailed in 2017.

We consider four main reasons for this unexpected result of an insignificant result for the association between the contract adoption variable and the average milk price received in 2017.

- 1) The share of total production in the fixed price contract can be quite low. In the case of Dairygold, the maximum share of production in any one contract was 15 per cent of total production in the reference year. The maximum share of production was 10 per cent in the case of Aurivo. Processors often allow some farmers to commit only 5 per cent of production to a fixed milk price contract.
- 2) Some farms only adopted fixed milk price contracts for a proportion of 2017.⁵
- 3) A combination of (1) and (2) whereby some farms allocated a small share of production to fixed milk price contracts for a select number of months during the calendar year.
- 4) The pro-cyclicality of higher fixed prices being offered in 2017 relative to 2016. This pro-cyclicality is likely to have reduced the difference between adopters and non-adopters in terms of the average milk price received. For instance, the Glanbia phase 9 scheme was introduced at the beginning of 2017 and offered a standardised milk price

⁵ For instance, Dairygold operated two separate fixed milk price schemes during 2017. The first scheme involved a standardised milk price of 30.2 cent per litre for up to 15% of 2015 milk supply. This scheme ended in August 2017 (Dairygold 2016, p. 5). The second scheme involved a standardised milk price of 30.75 cent per litre and operated from March to November 2017 (Dairygold 2017, p. 5.). Some Dairygold farm suppliers are likely to have participated in only one of these schemes. In the case of Glanbia, the phase 6 scheme is most relevant as this scheme ended in June 2017.

of 31.75 cent per litre, which was significantly above the fixed price of earlier offerings (Glanbia 2016b). Similar patterns are evident from other milk processors.

In addition to the above, there are winter bonuses and sustainability bonuses, which may be positively associated with the adoption decision in 2017. However, these bonuses are unlikely to have had a major bearing on the result. We have also explored the possibility that the solids performance was higher among the adopters. However, deeper analysis suggests that this is not an important factor in the result for 2017.

As in the case of 2016, the adopters of fixed milk price schemes in 2017 earned higher farm income (€99,302) than the non-adopters (€80,959). The change in farm income was significantly higher for adopters (€40,805) relative to non-adopters (€30,682). This suggests a greater level of expansion on farms, which adopted fixed milk price contracts relative to non-adopters. This finding also points to the possible role of production risk in influencing the adoption decision.

In 2017, we find that 51 per cent of the adopters of fixed milk price contracts were located in the Eastern region. By contrast, only 22 per cent of non-adopters were located on farms in the Eastern region. As in the case of 2016, these results are probably explained by the large presence of Glanbia in that region.

Table 4: Independent Sample T-Test Comparison of Adopters and Non-Adopters of FMP Contracts (2017)

	Non-Adopters	Adopters	Combined	Difference
Milk Price	36.58	36.35	36.49	-0.23
Family Farm Income [€]	80,959	99,302	88,086	18,343**
Change in Family Farm Income [€]	30,682	40,805	34,623	10,123**
Basic Payment (€)	15,161	18,076	16,294	2,915*
Litres of Milk Sold to the Creamery	353,773	447,898	390,340	94,126***
East Region (0,1)	0.22	0.51	0.33	0.29***
Sample Size [N]	132	91	223	

Source: Authors' calculations using the Teagasc National Farm Survey data

Note: *** denotes statistical significance at the 1% level, ** denotes statistical significance at the 5% level, * denotes statistical significance at the 10% level.

Based on the results for 2016 and 2017, it appears that fixed milk price contracts may have a limited impact on reducing farm income volatility. Research spanning multiple years for the same farm households will probably shed more light on the extent of impact over the medium to longer term. Given that many farms can only protect the milk price for a relatively small proportion of output, there is a case for a much more extensive toolbox of risk management tools to further reduce income volatility.

We have not explored the role of insurance products in managing price or income risk in Irish dairy farming. The CAP explicitly allows support for insurance premiums since 2009. While the 2013 CAP reform formally placed the risk management toolbox within the “second pillar”, the uptake of price/income insurance products in the livestock sector in Ireland is non-existent. Meuwissen et al (2018) provide a number of reasons for the relatively small farm insurance market in Europe in comparison to the United States. This situation may change in the future as private market insurance companies expand their offering. For example, in 2018, a UK-based company launched a milk price insurance scheme.⁶

6 Conclusions

Income volatility continues to pose a major challenge for Irish dairy farmers. Annual changes in excess of 30 per cent are now a common occurrence on many of these farms. While in absolute nominal terms, the dispersion has also grown through time with a widening in the absolute income gap between the highest income dairy farms and the lowest income dairy farms. For instance, the interquartile range was approximately €70,000 in 2017 in comparison to approximately €26,000 in 2001. The large unexpected income fluctuations in farm income can be problematic as access to credit and its subsequent repayment assume a greater degree of risk as there is increased uncertainty around cashflow and ultimately solvency. This is particularly true in times of expansion and investment, as witnessed by the Irish dairy sector in the period post the removal of milk quotas in 2015. However, the use of suitable risk management tools should help mitigate these negative effects by ensuring less volatile income streams.

In this paper, two risk management tools, which are currently available to Irish farmers, EU direct payments and the fixed milk price agreements, were considered in detail. The results suggest that farm income volatility, as measured by the arc percentage change, would have been notably higher in the absence of direct payments. The direct payments are particularly important for farms in the middle and bottom of the dairy farm income distribution. This supports the view that the EU provides a safety net in periods of low farm prices. However, the association between direct payments and farm income volatility appears to be waning in the aftermath of quota abolition as dairy farms become more market oriented and expand production.

The adoption of fixed price milk contract has been impressive with most milk processors now offering their suppliers an opportunity to forward sell part of their milk supply. Our results suggest that the adoption of fixed price milk contracts can have some important but limited impacts in terms of reducing farm income volatility. However, the power of contract adoption in influencing milk price volatility is tempered by a number of factors including the relatively small share of production that can be allocated to some contracts. There is further scope for more detailed research on the adoption of individual contracts, the volume of production committed to each contract and the counter-cyclicality of demand for fixed milk price

⁶ Information on the Stable can found on the company website <https://stableprice.com/>

contracts. Furthermore, there is scope to fully examine the causal relationship between contract adoption and farm income volatility using panel data estimation techniques.

Dairy farmers in the eastern region of the country in particular are availing of fixed milk price contracts. So, while farms in this region account for 33 per cent of the overall sample they account for 51 per cent of adopters of fixed milk price contracts in 2017. As discussed, this may reflect the fact that the largest processor in the area was the leader in providing these types of contract. In addition, adopters produce significantly larger volumes of creamery milk. Perhaps, the most significant finding is that family farm income is higher among the adopters (€99,302) relative to (€80,959) among the non-adopters in 2017. While the direction of causality is not established, the findings suggest that relatively higher income farmers are more likely to adopt fixed milk price contracts.

While this research measures income volatility and the adoption of suitable tools at the aggregate farm level, there is still a need to understand developments at the individual farm level. For example, the current research does not track the path of individual farmers during the survey period. The present analysis does not determine if some individual farmers experience continued high levels of income volatility while others are part of a cohort who do not.

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Appendix

In table 5, we show the average family farm income on specialist dairy farms (inclusive of direct payments) and the value of direct payments from 2005 to 2018. The direct payments exclude the disadvantaged area payments, which are decoupled payments. The direct payments also exclude the GLAS payments and the payments from the Rural Environmental Protection Scheme (REPS). It is evident from this data that the average family farm income on specialist dairy farms has been highly volatile since 2007. The direct payments component of the family farm income appears to be much more stable through time. The share of direct payments in farm income remained above 24 per cent with the exception of 2017. In 2009, the direct payments accounted for two thirds of family farm income on the average specialist dairy farms. This underlines the importance of the direct payments in stabilising overall dairy farm incomes during difficult times.

Table 5: Average Family Farm Income on Specialist Dairy Farms and Direct Payment 2005-2018

Year	Family Farm Income (€)	All Direct Payments	Percentage Share (%)
2005	39,937	11,163	28.0
2006	36,443	14,269	39.2
2007	51,731	14,775	28.6
2008	45,182	15,496	34.3
2009	23,794	15,862	66.7
2010	50,193	17,109	34.1
2011	66,964	17,788	26.6
2012	49,750	17,672	35.5
2013	62,920	17,282	27.5
2014	66,805	17,113	25.6
2015	63,928	15,958	25.0
2016	53,975	17,554	32.5
2017	88,755	16,678	18.8
2018	61,480	16,524	26.9

Source: Authors' calculations using the Teagasc National Farm Survey data

The Absolute Arc percentage change

The Absolute Arc percentage change in farm income differs from the standard year-on-year percentage change. In calculating the Arc percentage change, we express the change in farm

income relative to the average of two base years i.e. the average of the income from the current and previous year. This contrasts with the standard year-on-year percentage change in income, where the change in income is expressed relative to the preceding year only. A reliance on the standard year-on-year percentage change can result in the calculation of extreme percentage changes in income. These extreme values can be attributed to the reliance on a single base year for the calculation.

The Absolute Arc percentage change in farm income removes some of this problem by using the average of two years as the base period.

In formal mathematical terms, the absolute arc percentage change in farm income for each farm in each year is given in the following:

$$I_{it} = ABS \left[\left[\frac{100(Y_{it} - Y_{it-1})}{Y_{it}} \right] \right]$$

Where $Y_{it} = (Y_{it} + Y_{it-1})/2$ for each farm i with farm income Y_{it} in year t .