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Impact of Risk within the Northern Ireland Dairy Sector

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This paper examines farmers' decision-making under risk and uncertainty. In particular, the study identifies the type of risk preference (averse, neutral or seeking) and measures the magnitude of risk preference before and after the introduction of the Single Farm Payment (SFP). The analysis therefore provides an insight into the impact of this fundamental policy change on farmer risk behaviour. Furthermore, it examines agricultural production decision-making under price uncertainty. Empirically, it evaluates the impact of risk and uncertainty using Farm Business Survey (FBS) data of NI dairy farms.

Using an econometric approach (maximize expected utility), a comprehensive methodology is employed that enables price uncertainty and risk preference under the Common Agricultural Policy (CAP) to be analysed simultaneously. The methodology permits the testing of common risk aversion theoretical hypotheses, including Arrow's hypothesis on the effect of wealth on the measures of risk aversion. Also, this methodology enables the identification of the impact of farmers' attitude to risk, price uncertainty and other criteria (e.g. age, education, and family labour) on their production decisions.

The results are relevant to both policy makers and farmers. With regards to the former, the results reveal the factors which influence famers' decision making, therefore, enabling policy makers to evaluate the effectiveness and efficiency of agricultural policies and thus introduce improvements in future policies. With regards to farmers, the results demonstrate the consequences of risk and uncertainty on their operational environment.

1. Introduction and background

"Does risk really matter to agricultural producers?" Despite decades of research, this question is still raised by agricultural economists (see Just, 2002 and Goodwin, 2003). However, the answer is unambiguous - risk does matter to agricultural producers. Given the nature of agriculture systems, the owners of agricultural business cannot make decisions without considering risk.

Previous World Trade Organization (WTO) agreements have led to freer trade and future agreements will further remove trade restrictions. Against this background, the European Union's (EU) Common Agricultural Policy (CAP) has moved away from trade distorting measures (Amber box) towards the minimal or non-trade distorting category (Green box). In 1992, the MacSharry reforms transferred some of the support to agriculture from price support measures to direct payments in order to limit rising production. The Agenda 2000 reforms divided the CAP into two 'Pillars': production support and rural development support. Several rural development measures were introduced and agri-environment schemes became compulsory for every Member State. In June 2003, the CAP was fundamentally reformed with the introduction of decoupled direct payments (DDP) – the Single Farm Payments (SFP) under the Luxembourg Agreement. Under the SFP scheme farmers' production decisions should response more closely to market prices as subsidies are no longer linked to production. The SFP is subject to the fulfilment of criteria with respect to environmentally friendly farming practices, food safety and animal welfare standards. By moving support from the product to the producer, EU farmers are able to produce on the basis of what the market requires,.

However, as a consequence of progressive CAP reforms EU agricultural producers face increasing institutional risk operational environment. The Agenda 2000 reforms lowered producer prices by further reducing EU agricultural commodities intervention

prices and compensated for this by increasing direct payments. The introduction of the SFP under Luxembourg Agreement exposes EU agricultural producers to the even greater impact of market price variations.

NI dairy farmers face an extremely complex operational environment due to the combination of institutional risk and market price variations. A number of uncertainties surround their on farm decision making with respect to production and future investment. Moreover, NI dairy farmers will face greater potential uncertainty due to WTO negotiations (export subsidy elimination and import tariff reductions etc), EU expansion, milk quota abolition and the possibility of further reductions in intervention prices. Thus, in making production and investment decisions NI dairy farmers need to take account a host of uncertain factors, which have an impact on their income.

There are many types of risk in agriculture such as: production risk, price and market risk, institutional risk, financial risk and personal risk. It is important to understand how these risks impact upon production decisions. Different perceptions toward these risks can result in different attitudes to risk and hence different degrees of risk aversion. During the decision making process, farmers have to take account of the effects of risk. This implies that farmers allocate their investment capital and conduct their production activities to maximize the utility of their income or wealth, rather than to simply maximize expected profit.

Theoretically, decoupled payments should not distort markets and a government could use them without affecting either domestic or international markets. However, some risk research studies in agricultural production decision making have identified that decoupled payments might indirectly influence farmers' decision on production through wealth effects (Anton, 2000; and Paolo Sckokai, 2006). There are several reasons why the decoupled payments might affect farmer's productions. Firstly, the

fact that the SFP increases farm income may lead to changes in the degree of risk preferences of farm operators. Moreover, these changes in the degree of risk aversion might lead to adjustment of production. Secondly, the entitlements associated with the SFP might have positive effects on agricultural land value, hence could prevent land leaving agricultural sector. As a consequence, the SFP may provide an incentive to keep land in agricultural production. Finally, due to increasing wealth and land value, farmers' credit limitation might increase in order them to access more borrowing capital. Hence, the production decisions of farmers may be affected depending on how they utilise the funds provided by the SFP.

Risk and the attitude of the agricultural producer towards risk, are clearly important in agriculture and a key task is to manage risk effectively. If risk in agriculture is to be managed from a policy perspective, we must understand how risk and risk attitudes influence agricultural production. Despite the accepted importance of risk it remains, relatively speaking, a neglected area of research. Just (2002) states that "Risk research has not convinced many of its importance due to a focus on problems where risk is likely less important". The author goes on to list a number of risk issues in current agricultural economics research e.g. temporal and spatial aggregation problems, short-run versus longer-run problems and risk averse behaviour testing problem etc. He also discusses the choice of methodologies that have been applied to the analysis of agricultural production risk, e.g. duality approach, state-contingent utility, data envelopment analysis, stochastic dominance etc.

The primary objective of this study will be to examine price variation and institutional risk impacts on NI dairy farmers' risk attitude. Furthermore, this study investigates how different agricultural policy environments impact the degree of risk aversion and how this affects production decision-making. The results of this study are expected to provide practical information to both policy makers and farmers. For policy makers, the results of this should indicate type of criteria used by farmers in decision making.

Therefore, policy makers can evaluate the effectiveness and efficiency of agricultural policies in order to provide better support in the future. For farmers, the results of this study should suggest the consequences of risk and uncertainty in their operational environment.

Specifically, the main objectives of this paper are to:

- Explore farmers' perceptions of risk and risk management and to examine relationships between farm and farmer characteristics, risk perceptions, and strategies.
- Develop a model for production decision making and analysis under risks and risk preferences.
- Investigate the long-run implications on NI dairy farmers of EU CAP reform.

2. Review of the theory of risk aversion

Modes of decision making under risk bring to the forefront the fact that decisions will be affected by the agent's attitudes towards risk. Consequently, it is important to quantify the degree of agricultural producers' risk aversion.

Arrow (1971) and Pratt (1964) introduced measures of risk aversion. They established that, under the expected utility hypothesis, there exists a one-to-one relationship between preferences over random income (or wealth) and the measures of risk aversion. They defined:

$ARA = -U_{WW} / U_W$, a measure of absolute risk aversion and

$RRA = -(U_{WW} / U_W)W$, a measure of relative risk aversion,

Where W indicates total wealth and U_{WW} and U_W indicate the second and first derivatives of the Von Neumann-Morgenstern utility function, respectively. ARA and RRA are also known as the coefficient of absolute and relative risk aversion.

In the expected utility framework, attitude towards risk is defined in terms of the curvature of the utility function, $U(W)$. If the utility function of wealth (or income) is concave, $U_{WW} < 0$, the decision maker is risk averse. If the utility function of wealth (or income) is linear, $U_{WW} = 0$, the decision maker is risk indifference. If the utility function of wealth (or income) is concave, $U_{WW} > 0$, the decision maker is risk preference. In addition, the first derivative of the utility function for wealth (or income) is always positive, $U_W > 0$, and then it represents the situation of more wealth (or income) generating more satisfaction in terms of utility. They claim that, as income grows, one cares less about one `unit' of risk because the measure of absolute risk aversion is declining, but cares equally about the risk involving a given share of his wealth the measure of relative risk aversion may be constant and perhaps even equal to 1.

$\frac{-U''(W)}{U'(W)} = A(W)$ Absolute risk aversion and implies that initial wealth is variable.

$\frac{-U''(W)W}{U'(W)} = R(W)$ Relative risk aversion and implies that changes in scale of wealth-income and initial wealth are variables.

Elasticity of absolute risk aversion with respect to wealth is defined as:

$$\varepsilon_W^A = \frac{\partial A(W)}{\partial W}\frac{W}{A} = A'\frac{W}{A}$$

Elasticity of absolute risk aversion ε_W^A =0 indicates that the farmer is constant absolute risk aversion, Elasticity of absolute risk aversion ε_W^A <0 indicates that the farmer is decreasing absolute risk aversion, Elasticity of absolute risk aversion ε_W^A >0 indicates that the farmer is increasing absolute risk aversion.

Since $R(W) = A(W)W$, according to rules of differentiation where if $f(x) = g(x) \cdot h(x)$

Then $f'(x) = g'(x) \cdot h(x) + g(x) \cdot h'(x)$

We have $R'(W) = A'(W)W + A(W)W' = (\frac{A'(W)W}{A(W)} + 1)A(W)$ hence

$R'(W) = (\varepsilon_W^A + 1)A(W)$

Elasticity of absolute risk aversion ε_W^A =-1, where $R'(W) = 0$, indicates that the farmer is constant relative risk aversion, Elasticity of absolute risk aversion ε_W^A <-1, where $R'(W) < 0$, indicates that the farmer is decreasing relative risk aversion, Elasticity of absolute risk aversion ε_W^A >-1, where $R'(W) > 0$, indicates that the farmer is increasing relative risk aversion.

The analysis shows that the elasticity of absolute risk aversion with respect to wealth, ε_W^A, determines all the measures of risk aversion $A(W)$ and $R(W)$. Therefore once the measure of elasticity of absolute risk aversion has been obtained, the measures of risk aversion can be tested. Econometric procedures can be used to estimate the elasticity of absolute risk aversion.

3. Methodology

Several studies have attempted to model the effects of decoupled payments on agricultural (Oude Lansink and Peerlings, 1996; Guyomard *et al*., 1996; Moro and Sckokai, 1999). All of these studies have tried to take into account the partially "decoupled" nature of the compensatory payments introduced in 1992, typically modelling the land allocation mechanisms. However, one of the most important characteristics of these analyses is the assumption of risk neutrality, a common hypothesis in most studies based on applied duality theory, which does not allow the authors to explicitly take into account the impact of farmers' attitudes to risk.

Hennessy (1998) developed a comprehensive neo-classical framework for the analysis of agricultural income support policies under price uncertainty, analysing the behaviour of a competitive firm which maximises the expected utility of profit. Assuming farmers are risk averse, he defines the wealth effect under uncertainty as additional to the standard relative price effect of policies under certainty. If the policy affects the total wealth of the farmer, this change in wealth may affect the farmers' response to risk. The way in which wealth affects production decisions depends on individual risk preferences. If one assumes Decreasing Absolute Risk Aversion *(DARA)*, a common approach in modelling risk that assumes people are more willing to take on risk as their wealth increases, it can be shown that wealth-enhancing policies generate additional incentives to produce.

Coyle (1992 and 1999) proposed an extension of duality models applied to agricultural production in order to incorporate price and output uncertainty, assuming mean-variance risk preferences. This framework, although limited to the price uncertainty component under constant absolute risk aversion (CARA), has been applied by Oude Lansink (1999) to analyse the land allocation decisions of Dutch arable crop farms, but this study does not directly address the specific issues raised by the MacSharry package, since the model is estimated using data that refer to the pre-

reform period.

In the following section, using an econometric approach developed by Bar-Shira *et al*. (1997), we present a comprehensive methodology for the analysis of risk attitude of farmers and price risk under agricultural income support policy (Common Agricultural Policy) prior to and after the introduction of the decoupled Single Farm Payment. The methodology allows us to test common risk aversion theoretical hypotheses on assuming that farmers are risk averse (positive risk aversion) and Arrow's hypotheses on the effect of wealth on the measures of risk aversion (decreasing absolute and increasing relative risk aversion). Also, this methodology enables us to discriminate among the risk attitude of the farmer on his or her production decision and price risk and other criteria (social variables e.g. age, sex, education or family labour etc.). Specific hypotheses (objectives) can be tested using this econometric approach:

(1) estimate the measure farmer risk attitudes at the aggregate level over time by using NI farm business survey data;

(2) estimate the orders of magnitudes of the measures of risk aversion;

(3) estimate the effects of wealth changes on the measures; and

(4) estimate the effects of decoupling (CAP reform) on the change in risk attitude.

4. Data and empirical background

The dairy industry is a significant component of the Northern Ireland agricultural economy (see Table 1). Within the June 2007 Census there were 4151 dairy farms, with an average herd size of 69 cows. The average gross yield per cow per year stood at 6810 litres. The Northern Ireland dairy industry is mainly based on grass feeding due to the mild climate. The pasture based feeding method provides NI producers cost advantages compared with GB and other EU counterparts. The NI dairy industry is heavily dependent on export markets, with around 85% of its raw milk allocated to the production of dairy commodities (cheese, butter, SMP and WMP). The majority of the

commodites produced are sold outside of NI. Hence, the NI farm gate raw milk price fluctuates extensively with world commodity markets.

Table 1: NI dairy farms

	1984	1995	2007
Total number of dairy farms	8083	5409	4151
Total number of dairy cows	298,000	272,000	287,000
Average herd size	37	50	69
Average milk yield	4650	5240	6810

Source: DARDNI statistical reviews

Following the introduction of the milk quota in 1984, NI total milk output remained relative static prior to 1995. The raw milk price consistently declined following the deregulation of milk marketing board in 1995. Despite the lower raw milk price, the NI dairy industry expanded markedly due to low cost feed, availability of milk quota from GB and the easy accessibility of low cost loans. The expansion resulted from large and efficient farms getting bigger and the small and inefficient farms exiting the industry.

The balanced panel data used in this study are sourced from NI Farm Business Survey for the period of 1984 to 2007. Only dairy farms that have continuously provided information for entire period (1984 to 2007) are selected. In total 37 dairy farms fit these requirements. Selected variables include production side variables, socioeconomic variables, financial variables, wealth variables, etc. (see Appendix 1).

The milk production of the farms in the sample increased by 109 per cent between 1984 and 2007. The sample has a lower average milk yield (5940 litres/cow) compared with the NI national average (6810 litres/cow) in 2007. However, the average herd size in the sample (82 cows) is larger than the NI national average (69 cows).

Further variables of interest are discussed below:

Wealth and income

There are five measures of wealth and income in this study namely: total assets (TA), net worth (NW), total farm output (TFO), cash income (CI) and net farm income (NFI). Total assets consist of land & building, other fixed assets, trading livestock & stores, debtors & short-term lending, cash in hand at bank, other fixed assets machinery and other fixed assets breeding livestock. Net worth is equivalent to total assets minus external liabilities. Total farm output includes sales of livestock and livestock products, plus subsidies. Cash income is equivalent to total farm output less expenditure, which includes variable costs, general overheads, fuel, repairs, rent paid, paid labour & interest. Finally, net farm income is also considered as "tenant style" income. This is achieved by charging all imputed costs (such as, imputed value of unpaid labour, imputed rental value for owned land, depreciation of building and machinery, net change of livestock valuation and net interest payments).

Total debts to total assets ratio

Total debts consist of long-term debt (bank and other institutional loans and family & other loans) and short-term debt (bank overdraft, and other short term borrowing). Both short term debt and long term debt increased over the analytical period 1984 to 2007, however, the greatest increase occurred before the introduction of the decoupled payments. After the introduction of decoupled payments, NI dairy farms' short term debt and long term debt decreased by 49% and 15% respectively. This implies that NI dairy producers utilised their SFP to offset their debt. Total assets value increased over the analytical period, mostly due to increasing of value of land & building. From 1984 to1995, average total debts to total assets ratio of the sample of NI dairy farms is 4%. However after 1995 and before the introduction of the SFP, average total debts to total assets ratio increased to 8%. This increased amount has been used to invest fixed assets (land, build, machinery, and breeding herd) and purchase milk quota. After the introduction of the SFP, average total debts to total assets ratio retreated to the pre-

1995 level of around 4%. The lower level of total debts to total assets ration after the introduction of the SFP, suggests that there was less of an incentive for NI dairy farmer to further invest, but rather treat the SFP as a tool to reduce financial risk.

Fixed assets to total assets ratio

Dairy farms must purchase new fixed assets in order to grow. Since fixed assets can also be used to increase profitability, the ratio of fixed assets to total assets is considered in this study. Total assets of the NI dairy farms in this sample increased by 77% between 1984 and 1995 and 190% between 1995 and 2007. Over 1984 to 2007 total assets increased by 413%. However, the share of fixed assets to total assets ratio also increased. Prior to 1995 this share is relative static at around 90%, in contrast to an increase of approximately 94% to 97% between 1996 and 2007. After the introduction of the SFP, despite decreases of total debt level, the value of machinery and breeding cows continued to increase. These increases suggest NI dairy farmers in the sample viewed investment in fixed assets as a means to improve profitability (some empirical studies suggest that high profitability farms tend to increase share of fixed assets to total assets and in contrast low profitability farms tend to decrease share of fixed assets to total assets). The main investment in fixed assets occurred after 1995, during which NI dairy farmers could access the credit market at a relatively low cost. Specific loans from either the banks or milk processors were set up with repayments periods over 5 years at 1% over bank lending rate readily offered to NI dairy farmers wishing to expand. After 1995, significant quantities of milk quota were purchased from England. The increases in investment should improve productivity by substituting new fixed assets for labour or aging fixed assets. Also, highly profitable farms are more likely to increase fixed assets purchases when their equity grows, whereas low profitable farms tend to let equity accumulate.

Farm size

Over the analytical period the farming area of NI dairy farms in the sample grew gradually. Total farming area increased by 38% between 1984 and 2007. In 1984, the average total farming area is 48 hectares, while in 2007 the average total farming area is 67 hectares. However, the increases of total farming area are mainly accounted by increases of area of taken (rented) from other farms to expand production. The rented area increased by about 81% between 1984 and 2007. During 1984 to 2007, 249 observations are defined as large farms in which the farming area is greater or equal to 65 hectares, 394 observations defined as medium farms in which the farming area is less than 65 hectares but greater than 40 hectares and 247 observations defined as small farms in which the farming area is less or equal to 40 hectares. The average dairy herd size in the sample is 55 in 1984 and it increased to 82 in 2007 (an increase of 50%). Dairy cow numbers per hectare are included within the analysis to examine the policy introduction of maximum nitrogen loadings. The increase in the rate for dairy numbers is higher than that for total farming area, implying farmers in the sample tend to expand their production and improve efficiency. Cow numbers per hectare in the sample (1.2) show less than approximate maximum dairy cow numbers (1.5) per hectare requirement to comply with 170 kg N/ha/year limit.

Location

There are 6 counties in Northern Ireland. The dairy farms in our sample are distributed as follows: County Tyrone (291 observations), Fermanagh (283 observations), Derry (168 observations), Antrim (96 observations), Down (50 observations) and none in county Armagh.

Levy

The superlevy is a supplementary levy which the farmer may have to pay on every litre of milk he or she produces in excess of his or her quota. Note, it is only imposed if total UK milk production exceeds the total UK quota. Over the expansion period

(after 1995) NI dairy farms purchased significant quantities of milk quota and hence the impact of the superlevy (107 observations) on NI milk production is relatively small.

LFA status

In this study a LFA dummy is used to indicate land quality. Most of the farms (70%) in the sample are classified as LFA (619 observations).

Family labour unit

Family labour unit equivalent is calculated with total family labour working hours divided by 1900 hours. This variable is used as a measurement of the level of engagement of dairy farming business (how hard family labour works).

Off-farm income

Nearly 60% of observations have off-farm income (519 observations).

Own land ratio

This variable is calculated by dividing own land area by total land area. Despite the increasing farm size, the own land ratio decrease from 2000. This might reflect dairy farmers renting land to expand their production.

Agricultural education dummy

Only 13 observations received an agricultural education.

Age dummy,

Farmers aged younger than 45 account for 192 observations, between 46 to 55 262 observations, between 55 to 65 256 observations, between 66-75 148 observations and over 75 30 observations.

5. Results

The following discussion focuses on the results related to the wealth variable of ENW (expected net worth), which is most consistent with Arrow-Pratt's definition of wealth- the value of all assets. Upon carrying out statistical tests and regression analysis, the wealth variable ENFI has been excluded due to the test of correlation coefficient t-value, which indicates statistical insignificance at the desired (95%) significant level. It is likely that this is largely due to that ENFI measures a tenant style of income which treats all the imputed costs as real costs. The second excluded wealth variable is ETFO, which causes endogenity problems as the measurement of ETFO (value of milk output plus subsidies) is almost equivalent to value of milk output. The final excluded wealth variable is ETA since the regression results associated with the ETA wealth variable are almost identical to the regression results with the associated ENW wealth variable. Future analysis will also consider the wealth variable ECI (expected cash income).

Panel data study regressions (see Appendix 2) on the sample of NI dairy farms with selected interval periods (1987 to 2007, 1987 to 2004 and 2005 to 2007) and different measures of farm wealth have been carried out in order to identify the impacts of the introduction of the SFP on farmers' risk attitude. The first finding is that the elasticity of ARA (see Table 2) with the associated wealth variable of ENW are -0.312 for the entire analysis period (1987 to 2007), -0.361 for the period before the introduction of the SFP (1987 to 2004), and -0.3 for the post introduction of the SFP period (2005 to 2007) if we allow the SFP to be treated as a wealth effect. Using the alternative measure of wealth ENW, in which farmers treat the SFP as a non-production related income and also assume the SFP has no direct or indirect affects on production or farm risk management (we exclude the SFP altogether), the elasticity of ARA of ENW is -0.254. Furthermore, if we allow the SFP to have some indirect effects through farm risk management, the elasticity of ARA of ENW is -0.275. The statistical tests show that all the elasticities are significantly different from zero as

well as from -1. As a result, the results demonstrate that NI dairy farmers in the sample are risk averse and indicate decreasing absolute risk aversion (DARA) and increasing relative risk aversion (IRRA). The results comply with Arrow's hypotheses on the effect of wealth on the measures of risk aversion (decreasing absolute and increasing relative risk aversion). Our results are also consistent with other empirical study findings. Binswanger's (1981) estimation of elasticity of ARA with respect to wealth was -0.32 using an experimental approach, while Bar-Shira's (1997) estimation of elasticity of ARA with respect to wealth was -0.316 by using an econometric approach. The range of our elasticities of ARA are between -0.254 to -0.361 using ENW as a wealth variable. The Wald's coefficient restrictions tests suggest that the elasticities are not significantly different from each other prior to and after the SFP policy introduction. The results suggest the wealth effects of the SFP on production are marginal.

Table 2: Elasticity of ARA, ARA, and RRA

				ENW		
Elasticity of ARA			87--07	**-0.312501**		
Elasticity of ARA			87--04	**-0.360495**		
Elasticity of ARA (SFP in Wealth Variable)			05--07	-0.299745		
Elasticity of ARA (SFP excluded from regression)			05--07	-0.253989		
Elasticity of ARA (SFP in total debt)			05--07	**-0.274531**		
RRA			87--07	**7.497560164**		
RRA			87--04	**6.476642487**		
RRA (SFP in Wealth Variable)			05--07	1.297123783		
RRA (SFP excluded from regression)			05--07	1.840644967		
RRA (SFP in total debt)			05--07	**5.949594411**		
Classification for relative risk aversion due to Anderson and Dillon (1992)						
RRA	0.5	1	2	3	4	
The rate of risk aversion	low	normal	high	very high	extreme high	
Classification for relative risk aversion due to Hardaker et al. (2004)						
RRA	0	0.5	1	2	3	4
Maximum stake percent of wealth	20%	18%	17%	14%	12%	11%

The magnitudes of the measures of risk aversion can be identified through the calculation of coefficients of RRA with respect to the wealth variable. The results for the coefficients of RRA (see Table 2) indicate that the magnitudes of RRA reduced post the introduction of the decoupled payments under all different treatments of the SFP (i.e. production related through wealth, non-production related and no indirect effects on production, or with some indirect effects through farm risk management). With regards to the treatment of the SFP with production related through wealth, the coefficient of RRA reduces significantly to 1.297. This suggests that there is a significant change in NI dairy farmers' risk attitude through wealth effects for post introduction of the SFP. However, further investigation suggests that it is inappropriate to conclusively infer that the reductions of magnitudes of RRA were caused by the introduction of the SFP. Similar results can be found if we treat the SFP as non-production related income and has no direct or indirect effects on production, the coefficient of RRA reduces to 1.841. Thus, the coefficients of RRA decline with or without the SFP incorporated in the wealth variable. Because the SFP is small (only represents 1.5% to 2.5% of farm net worth) relative to net worth on the sample of dairy farms and most of the increases of net worth over the period 2005 to 2007 are due to increasing farm land value rather than introduction of the SFP. With regards to the treatment of the SFP with indirect effects through farm risk management, the coefficient of RRA falls slightly to 5.950. Under this approach the statistical significance of some of the key variables improves. The results for treating the SFP in this way may suggest that the decoupled payments have a limited impact on farmers' risk attitude, i.e. the wealth effects of the SFP on output are minor. The decrease in risk aversion may be due to increases of value of other farm assets or market returns. Moreover, the magnitudes of RRA of NI representative dairy farmers remain within the category extremely high after 2005, according to Anderson and Dillon's (1992) classification.

The second important finding is that the variable 'Debts' (see Appendix 2) plays a significant role on the production decisions of NI dairy farms. The coefficients of 'Debt' are significant at all the critical statistical levels for regressions over the entire analysis period or prior to the SFP introduction. The values of the coefficients are around 0.05 using the wealth measure ENW, with a positive sign. This finding is consistent with the observation that NI dairy farmers utilise debts to finance their investment on dairy production (debt per cow increased from 1995 and decreased after 2005, and similar pattern for debt to total assets ratio), especially after 1995. The coefficients for debts become insignificant after the introduction of decoupled payments, which suggests functional form problems or structural change due to the introduction of the SFP. As noted in the previous section, the variable debt to total assets ratio changes over the sample period. After the introduction of the SFP, the average total debts to total assets ratio falls to pre-1995 levels from 8% to 4%. In addition, the average milk output did not decrease as the total debt level fell. This suggests that NI dairy famers utilised the SFP to reduce their debt level to maintain healthy financial leverage and reduce financial risk in the environment of continuously decreasing profit margin per litre (between 1995 and 2006 the farm gate milk price per litre in NI continuously falls with relatively static variable cost per litre over the same period).

If the SFP is allocated to finance total debts (SFP in total debt), the significance level for the debt coefficients improves. Using the wealth measure ENW, the probability level of the coefficient of debt increases from 0.72 (treat SFP production related) and 0.84 (treat SFP non-production related) to 0.11. In addition, the coefficient value of debt changes from 0.016 (p-value: 0.72) and 0.009 (p-value: 0.84) to 0.111 (p-value: 0.11). These results suggest that NI dairy farmers treat the SFP as a tool to reduce financial risk and maintain a regular rate of production expansion (e.g. even without the SFP, NI representative dairy farms might keep similar debts to total assets ratio or similar amount of debts to expand or keep their production level rather than reduce

total debts significantly). However under this approach, there is less evidence to suggest that the SFP significantly impacts milk production in the short term. We cannot exclude the possibility of its impact on milk production in the longer run, once the market return of raw milk improves and increases in the debt to total assets ratio finances milk production expansion.

The estimated effects of the variables expected profit and variance of profit (see Appendix 2) on production decision are small. Only the estimation result for expected profit for the entire analysis period is significant and the value is 0.142 using the wealth measure expected net worth. With respect to the other regressions, the results are statistically insignificant for the coefficients of expected profit. In order to examine the impact of price risk on production decisions we incorporate the variance of expected profit variable. The estimation of expected profit variance suggests that price risk has a marginal impact on production decisions. The impacts of price and price risk on production decisions are small, which complies with our observations. After deregulation of the milk marketing board in 1995, despite the NI average farm gate milk price decreasing from 25.4 pence per litre in 1995 to 16.8 pence per litre in 2006, NI milk production increased from 1381 million litres in 1995 to 1909 million litres in 2006. The main drivers of milk production expansion during this period were less regulation compared to the Republic or Ireland, the low cost feeding system, variability of skilled family labour, availability of milk quota from GB and easy accessibility of low cost loans. The above results for profit and variance of profit may reflect the balanced nature of the data set and resulting inclusion of only dairy farmers who remain within the Farm Business Survey over the entire sample period. The sample thus excludes farmers who may have exited the dairy industry. The results for these variables may differ if an unbalanced data set is employed, which includes more observations. Future analysis will look at this issue.

The effects of farmer socio-economic variables (see Appendix 2) on milk production decision are mixed. Our findings suggest that farm size, family labour, age of farm owner, dummy for the introduction of decoupled payments period and location of county Fermanagh significantly influence milk production decisions. Unsurprisingly, farm size has a positive effect on milk production. Family labour, which measures working hours, has a positive impact and is significant at all the desired statistical levels. The magnitudes for the age of farm owner variables on production are similar for the age groups within 45 to 65. In general, the variable for the age group 66 to 75 has smaller coefficients compared to the age groups within 45 to 65. Farmers within this age group are at retirement stage and thus the production decisions are perhaps made by their successor but they are still the legitimate owner of the farm. The coefficient for the dummy variables for the period of the introduction of the decoupled payments is significant and has a positive effect on production. However, as discussed in the above section, this positive effect cannot necessarily be attributed to the introduction of the SFP. The location variable Fermanagh has a negative and significant effect on production decision. This is consistent with the climatic conditions in Fermanagh, which are wetter than the rest of NI.

The effects of some of the other socio-economic variables on milk production are insignificant or are inconsistence across different regressions. This includes variables such as fixed to total assets ratio, owned land ratio, LFA dummy, location dummies for Antrim, Tyrone, and Derry, agricultural education dummy, off-farm income dummy, and superlevy dummy. The insignificant regression results for these variables suggests that the regression equations might require modification through dropping out some of the variables or redefining some of these variables in order to improve functional form. The results for socio-economic variables may change when an unbalanced data set is used as a basis for the analysis.

6. Conclusions

This study uses an econometric approach to analyse the risk attitude of farmers and price risk under agricultural income support policy (Common Agricultural Policy) prior to and after the introduction of the decoupled Single Farm Payment. The balanced panel data taken from 37 dairy farms in the NI farm business survey are used in an econometric regression estimated over the period of 1984 to 2007. Some interesting findings emerge from the econometric regressions. The main finding is that NI dairy farmers exhibit decreasing absolute risk aversion (DARA) and increasing relative risk aversion (IRRA) and thereby provide support for Arrow's hypotheses. Examination of the elasticities of absolute risk aversion using different treatment of the SFP indicates that the wealth effects of the SFP on production are marginal both before and after the introduction of the decoupled payments. Under different treatments of the SFP, the results of coefficients of relative risk aversion with respect to wealth are diverse. If we treat the SFP coupled or decoupled from production through wealth and without any other indirect effects, the coefficients of RRA reduced significantly to similar level, which suggests the SFP has little impact on NI dairy farmers risk attitude and the decrease of the coefficients of RRA may be caused by an increase of other wealth assets. However, it is also apparent that some of the key variables (particularly 'Debts') in the regression become insignificant. Based on our observation, debts play a very important role for financing milk production expansion especially after deregulation of Milk Marketing Board. If the SFP is treated as a tool which has indirect effects through farm risk management, the results for the coefficient of RRA changed marginally before and after the introduction of the SFP and the statistical significance for the coefficient of the 'Debt' variable improves. Under this treatment the results suggest that NI dairy farmers treat the SFP as a tool to reduce financial risk and maintain a regular rate of production expansion. Also, the results imply the SFP impacts milk production in the longer run through increasing the debt to total assets ratio. The estimated effects of the variables

expected profit and variance of profit on production decisions are small, which may be due to the balanced nature of the data set. Some socio-economic variables have significant effects on production decisions but the regression equations may need to be modified further to determine the impact of the other socio-economic variables.

Appendix 1: Definition of the variables used in the analysis

	CODE	Dependent variable	units	Description
1	MOL	Milk output litres	Litres	Milk output litres
		Independent variables		
		Expected wealth variables		Value of wealth variables include the SFP after year 2005 (inclusive)
2	ETA	Total asset	Pounds	total assets
3	ENW	Net worth	Pounds	total assets - external liabilities
4	ETFO	Total farm output	Pounds	Output value (market receipts) + subsidies
5	ECI	Cash income	Pounds	Receipts - expenditure (which include, variable cost, general overheads, fuel, repairs, rent paid, paid labour and interest)
6	ENFI	Net farm income	Pounds	Tenant type asset
		Expected net profit and variation		
7	ADAPTIVE3TO1	Expected net profit per litre	Pence	$Ep_t = rp_{t-1} + r^2 p_{t-2} + r^3 p_{t-3}$ $where..r + r^2 + r^3 = 1$
8	ADAPTIVE3TO1VAR	Variance of expected net profit per litre		$VarEp_t = Var(Ep_t, p_{t-1}, p_{t-2})$
		Financial situation		
9	DTAR	Debt to total asset ratio	Ratio	Total debt/total asset
	or TD	Total debt	Pounds	Log(total debt) Or Log(total debt + SFP)
		Farm size		
10	LARGE	Farm size	Dummy	Take the value of 1 if the farm is large size, 0 other wise (measure by acreage larger = than 65 hectares)
11	MEDIUM	Farm size	Dummy	Take the value of 1 if the farm is medium size, 0 other wise (large than 40 and smaller than 65 hectares)

	CODE		units	Description
12	SMALL	Farm size	Dummy	Take the value of 1 if the farm is small size, 0 other wise (less = than 40 hectares)
		Region		
13	ANTRIM	Geo-location	Dummy	Take the value of 1 if the farm is in Antrim
14	ARMAGH	Geo-location	Dummy	Take the value of 1 if the farm is in Armagh
15	DOWN	Geo-location	Dummy	Take the value of 1 if the farm is in Down
16	FERMANAGH	Geo-location	Dummy	Take the value of 1 if the farm is in Fermanagh
17	LONDONDERRY	Geo-location	Dummy	Take the value of 1 if the farm is in Londonderry
18	TYRONE	Geo-location	Dummy	Take the value of 1 if the farm is in Tyrone
		Levy		
19	LEVY	Super levy	Dummy	Take the value of 1 if the milk production exceed quota, 0 otherwise.
		LFA area		
20	LFADUMMY	LFA status	Dummy	Take the value of 1 if the farmland is mainly in LFA
21	LOWDUMMY	LFA status	Dummy	Take the value of 1 if the farmland is mainly in Low land
		Characteristic variables		
22	LABF	Family labour	Hours/1900	Labour unit equivalent calculated with total family labour working hour divided by 1900 hours
23	OFFINC	Off farm income	Dummy	Take the value of 1 if the farm is receiving off-farm income, 0 otherwise.
24	OLR	Percentage of land ownership	Ratio	Own land area /total land area
25	FTAR	Fixed asset to total asset ratio	Ratio	Fixed asset/total asset
26	AGRIEDUDUMMY	Education level	Dummy	Take the value of 1 if the farmer is receiving agricultural education, 0 otherwise.

	CODE		units	Description
27	AGE45	Farmer's age	Dummy	Take the value of 1 if the farmer's age is younger than 45 (inclusive), 0 otherwise.
28	AGE4655	Farmer's age	Dummy	Take the value of 1 if the farmer's age is between 46 and 55 (inclusive), 0 otherwise.
29	AGE5665	Farmer's age	Dummy	Take the value of 1 if the farmer's age is between 56 and 65 (inclusive), 0 otherwise.
30	AGE6675	Farmer's age	Dummy	Take the value of 1 if the farmer's age is between 66 and 75 (inclusive), 0 otherwise.
31	AGE75	Farmer's age	Dummy	Take the value of 1 if the farmer's age is older than 75, 0 otherwise.

Appendix 2: Regressions results with different wealth variables

	87--07	87--04	05--07	05--07	05--07
	ENW	ENW	ENW	ENW	ENW
Variable	Coefficient	Coefficient	Coefficient	Coefficient	Coefficient
			Production related	Non-production related	Indirect effect through risk management
C	6.745906**	6.225423**	8.983107**	9.482967**	8.031839**
Wealth variables	0.312501**	0.360495**	0.299745**	0.253989**	0.274531**
Expected profit	0.142261**	0.083571*	0.142775	0.142447	0.182774
Expected variance of profit	-0.01019	-0.00808	-0.02501	-0.01935	-0.01455
Large>65	0.752825**	0.726069**	0.729308**	0.753681**	0.657907**
40<Medium<65	0.306855**	0.300601**	0.284756**	0.278483**	0.238866*
Total debt **(+SFP#)**	0.051675**	0.054443**	0.015701	0.008796	**0.110945#**
Fixed assets/total assets	0.385967	0.487133	-2.02452	-1.95902	-1.62247
Family labour	0.076655**	0.057202**	0.202461**	0.218623**	0.177072**
Owned land/total farming area	0.091476	0.155795**	0.077404	0.124952	0.051712
LFA dummy	0.015656	0.016348	0.039962	0.045645	0.044469
ANTRIM	-0.11838*	-0.14373*	0.084108	0.103567	0.041823
FERMANAGH	-0.26958**	-0.26454**	-0.14285	-0.12006	-0.2044
TYRONE	-0.13517**	-0.16525**	0.250768	0.252776	0.217966
DERRY	-0.09235*	-0.13703**	0.111109	0.109925	0.022725
AGE45	0.276532**	0.237533**	0.354171*	0.412537**	0.364852*
AGE4655	0.252201**	0.215137**	0.36868**	0.391216**	0.317607**
AGE5665	0.244362**	0.20866**	0.448754**	0.462589**	0.402546**
AGE6675	0.101877*	0.035582	0.526032**	0.536422**	0.516627**
AGRIEDUDUMMY	0.010036	0.133923	0.199182	0.237502	0.105404
OFFINC	-0.03355	-0.03645	0.006276	0.011599	0.0374
LEVY	-0.04025	-0.03203			
DDP	0.159074**				
R-squared	0.869857	0.867924	0.915417	0.921652	0.921652
Adjusted R-squared	0.864834	0.86241	0.879425	0.887588	0.887588

** Significant at 95% probability level, * Significant at 90% probability level

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