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May 2011

Grantham Research Institute on Climate Change and the Environment

Working Paper No. 48

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Risk Preferences and Voluntary Agri-environmental Schemes: Does Risk Aversion Explain the Uptake of the Rural Environment Protection Scheme?

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ABSTRACT

The lowering of trade barriers under the successive reforms of the pillar I of the Common Agricultural Policy, the opening of the commodity markets to an ever greater number of financial actors and the uncertainty created by climate change, amplify both production risk and market risks for producers. This is particularly true for Irish dairy farmers, as they are export-oriented and their grass-based production system is closely linked to the cycle of seasons. The Rural Environment Protection Scheme (REPS), part of the agri-environmental policies of pillar II, offers to farmers an opportunity to stabilize their income over a five year period. We estimate risk preferences with the model of Antle (Antle, 1987) in order to analyse the impact of risk aversion (relative risk premium) on the probability of joining REPS. Our results support the hypothesis that REPS is used as a risk management tools. This sheds light on the interaction between the reforms of pillar I and the ones of pillar II: further increases in risk could increase the uptake of voluntary agri-environmental policies while the development of new risk management tools (revenue insurance, forward contracts, etc) could decrease it as they could both become substitutes.

INTRODUCTION

The lowering of trade barriers under the successive reforms of the pillar I of the Common Agricultural Policy (CAP), the opening of the soft commodity markets to an ever greater number of financial actors and the uncertainty created by weather risk and climate change amplify both production risk and market risks for agricultural producers. This is particularly true for Irish dairy farmers, as they are export-oriented and their grass-based production system is closely linked to the cycle of seasons. Since the reform brought by the Agenda 2000, the policies of the CAP are divided between the pillar I and pillar II covering respectively production support policies and rural development policies. The present paper contributes to the understanding of the interaction between pillar I and pillar II by linking the participation to a pillar II scheme, the Rural Environment Protection Scheme (REPS), with risk preferences. REPS is a voluntary agri-environmental scheme initiated in 1994 and closed in 2009 to new entrants. It rewards farmers financially over five years for adopting environmentally friendly practices.

Our hypothesis is that the increase in risk brought by the successive reforms of pillar I creates a demand for income stabilizing mechanism that REPS satisfies by offering a secure source of income over a long period. Therefore, a large determinant of the uptake of REPS is the demand for risk management mechanisms. We test this hypothesis by estimating the impact of farmers' relative risk premium on the probability of joining REPS. The relative risk premium is estimated with the model of Antle (Antle, 1987), more recently used by Franklin et al, Ben Groom et al. and Johannes Sauer (Franklin et al., 2006, Groom et al, 2008, Sauer, 2011). Although several studies have analyzed the interaction between agricultural support policies and environmental policies, no work has analyzed the link between voluntary agri-environmental policies similar to REPS and risk preferences. The present paper provides tools for understanding this dynamics, likely to be more patent over the next decade as market risk and production risk are likely to increase with further trade liberalization, the phasing out of the quota in 2015 and, in a longer term, climate change.

There are different types of risk threatening a farm business (Hardeker et al., 2004): market risks (e.g. price volatility, demand shock), production risk (e.g. weather variability, pest and animal disease etc.), institutional risk (e.g. change in policy), financial risk (e.g. change in interests charged on the debt of the farm) and personal risk (e.g. health, accidents, divorce). Here, we focus only on market risk and production risk. Let us start by introducing the impact of those risks on the production choices before presenting briefly REPS.

When a farmer chooses his input, he also chooses the range of profit he might expect. For instance, if he borrows largely to invest in lands, buildings stock, and new machinery, he might hope selling at a good price his production while taking the risk of suffering losses if the price turns out to be low (market risk) or if an epidemic hits his herd or poor weather reduces yields (production risk). However, if he prefers a conservative production plan, his exposure to risk diminishes as well as his expected profit. In other words, the farmer engages in a trade-off between marginal increase in mean and marginal increase in variance while choosing his input. Risk averse farmers tend to select input choices which decrease the variance of income at the cost of expected profit, to adopt diversification strategies at the cost of economy of scale, to have a low rate of adoption of new technologies and innovative farming practices. In term of dairy production, it translates in smaller stocking rate, less efficient use of labor, smaller production scale, off-farm job to diversify the source of revenues or, as we argue, participation to agri-environmental scheme stabilizing income at the cost of lower expected margin on the dairy enterprise. As these trade-offs between mean and variance are determined by the aversion to risk, the impact of each input mix on each farmer’s profit and risk offers an indication of his level of risk aversion.

The goal of REPS is to incentivize farmers to adopt environmental friendly farming practices which preserve landscape, wildlife habitats and protect endangered species while producing quality food in an extensive manner. The main characteristics of REPS is that it is universal (all farms can enter the scheme and not only the one located in environmental sensitive area) and it is voluntary (Emerson and Gillmor, 1999). Farmers have to draw a five years action plan to apply a comprehensive set of eleven mandatory measures reaching from waste management, fertilizers uses and stocking rate to the protection of wildlife habitats, historical remains and the improvement of the visual appearance of the farm (Emerson and Gillmor, 1999). In the last version of REPS, two additional biodiversity measures had to be adopted (Scheme and Service 2005, Department of Agriculture and Food, Ireland). On the conditions of the fulfillment of the plan, farmers receive €200/hectares for the first 20 hectares (ha), €175/ha for the next 20 ha up to 40ha, €70/ha for the next 15 ha up to 55 ha and €10 ha for areas over 55 ha. Higher payments are given to environmental sensitive area (Target Area). The non-respect of the engagement might lead to a fine and ultimately to the exclusion from the scheme. Supplementary measures such as organic farming practices might lead to additional payment.

In the second section, we present a short literature review; in the third part, the model of Antle; in the fourth part, the econometric method; in the fifth part the data; in the sixth part, the results and in the seventh part we discuss them and conclude.

LITTERATURE REVIEW

The econometric estimation of risk preferences based on production decisions has produced a significant literature (Saha, 1997, Antle, 1987, Groom et al., 2008, Antle, 1989, Chavas and Holt, 1996, Love and Buccola, 1991, Lence, 2000, Pennings and Garcia, 2001, Kumbhakar and Tveterås, 2003, Kumbhakar, 2002b, Kumbhakar, 2002a, Appelbaum and Ullah, 1997, Kumbhakar and Tsionas, 2010, Antle, 2010, Lence, 2009).

The result of most of these studies is that farmers are risk averse and exhibit declining absolute risk aversion (DARA). However, the level of risk aversion is significantly smaller in developed countries than in developing countries, approaching risk neutrality and even risk loving behavior in one study in a developed country (Koundouri et al., 2009). This is explained by the generous and expensive subsidies which have succeeded in sheltering the agricultural sector of the countries of the Organization for Economic Co-operation and Development (OECD) from a large part of market risk and production risk.

Several studies have investigated the impact on risk preferences of the successive reforms of the market support policies and production subsidies. These reforms, started with the MacSharry reform in 1992 and continued with the Agenda 2000 and the Luxembourg Agreement in 2003, have consisted in the lowering of trade barrier and ultimately in the decoupling of subsidies from the production level. The general lesson is that decoupled direct payments distort much less production decision than price support policies (Sckokai and Moro, 2009, Sckokai and Moro, 2006, MORO et al., 1999, Koundouri et al., 2009, Boyle et al., Goodwin and Mishra, 2006).

The models of risk preference estimation mainly differ in their specification of the utility function. They are all framed in the maximum expected utility theory first formalized by Bernoulli in 1778 (Bernoulli, 1954) and reintroduced in the economics' literature by Von Neumann and Morgenstern (1944) (Neumann and Morgenstern, 2004), despite the long ongoing debate started at the end of the 70's on the ability of this theory to represent correctly human behavior (Kahneman and Tversky, 1979). Recently, the validity of these models have been seriously called into question by Lence (Lence, 2009) and Just et al.(Just et al., 2010). Although the model we use is the more robust to this string of critics, new models need to be developed. The present paper, although being very orthodox in terms of method, sheds new light on the role of risk preferences in policy design.

The determinants of the large uptake of the different policies of pillar II (such as REPS) has been analyzed in several quantitative studies (Hynes and Garvey, 2009, Defrancesco et al., 2008, Wossink and van Wenum, 2003, Vanslembrouck et al., 2002, Wilson, 1997) and qualitative ones (Wilson and Hart, 2001, Gorman et al., 2001). The main conclusion is that farmers join REPS and other voluntary agri-environmental schemes of pillar II because of the financial advantages they provide rather than for environmental concerns. However, these studies have not investigated the role of risk. Other studies have investigated the interaction between agricultural support policies and agri-environmental policies (Just and Antle, 1990, Isik, 2002). However, they have mainly addressed environmental policies based and tax and pollution permits rather than agri-environmental policies similar to REPS. Understanding the dynamic relationship between REPS and risk aversion could help shed light on the interaction between pillar I and pillar II.

THE ANTLE MODEL

The output of the model of Antle (Antle, 1987) is an estimate of risk preferences at the population average. As highlighted in the introduction, farmers engage in a trade-off between expected mean and variance of gross margin when choosing their inputs. This trade-off is determined by the aversion to risk. The model of Antle rests on the assumption that the population of *N* farmers where each makes a bet on his input mix is equivalent to one farmer making *N* bets in *N* lotteries. Based on the observed production choices, we estimate the level of risk aversion explaining the best the relation between individual risks and choices. In other terms, we estimate the risk aversion at the population average.

More formally, the producer is assumed to maximize the expected utility of profit:

$$\max_{X} EU(\pi) = \max_{X} \int U[pf(\varepsilon, X) - w'X]\, dG$$

where $G(x, z, \gamma | \bar{x}, \bar{z}, \theta)$ is the joint distribution of the variable input, X , fixed input, Z , and risk attitude, γ . We don't assume any particular functional form for this distribution because we rely on the flexible moment approach of the model of Antle (Antle, 1987). The complete derivation is left in the Appendix A, here it is enough to present the main equation which is the first order condition (FOC) expressed in terms of the moments:

$$\frac{\partial \mu_1}{\partial x_k} = \left(\frac{1}{2}\right) AP \frac{\partial \mu_2}{\partial x_k} + \left(-\frac{1}{6}\right) DS \frac{\partial \mu_3}{\partial x_k} + u$$

Where μ_1 is the mean of the profit distribution of each farmer, μ_2 its variance, μ_3 its skewness, x_k the input k, AP the coefficient of absolute risk aversion (Pratt, 1964), DS the coefficient of downside risk aversion (Menezes et al., 1980) and u is the error term. As we see, the FOC equation captures the trade-off between mean and variance we presented in the introduction and first paragraph of this section.

The estimated AP and DS allows computing the risk premium. The risk premium is expressed as (see appendix B for the derivation):

$$R = \frac{1}{2}\mu_{2k}AP - \frac{1}{6}\mu_{3k}DS$$

The risk premium might be interpreted as the willingness to pay to be insured (Chavas, 2004) or as the demand for risk management tool.

ESTIMATION STRATEGY

In order to estimate the coefficient of absolute aversion (AP) and the coefficient of downside risk aversion (DS), we need first to build the system of first order condition (FOC) derived with the model of Antle. The econometric model has thus two parts. The first part is composed by 3 equations forming the stochastic revenue function: the conditional expectation, the conditional variance and the conditional skewness. We obtain the estimate of the impact of each input on the three first moments of the distribution of profit (mean, variance, skewness). These estimates allow computing the marginal effect (ME) of each variable on three first moments of profit. The second part of the model is the system of FOC derived in the model of Antle: the ME are the variables and the AP and DS are the parameter to be estimated. The results of the first part are therefore the building blocks of the second part of the model.

The first challenge is to estimate the impact of input choice on risk. We start by specifying a stochastic revenue function (Just and Pope, 1979, Di Falco and Chavas, 2006, Groom et al., 2008, Di Falco and Chavas, 2009, Antle, 1983). We use the square and the cube of the residual as proxy for the variance and skewness of profit. Indeed, the residuals of a regression are what is left unexplained for each farmer given the observed level of inputs' uses and the input-gross margin relationship in the rest of the sample. Assuming that the model is correctly specified, the residual is the difference between what actually happened and what each farmer might have expect from his input use given the input-output relations observed elsewhere in the population. This is therefore a good proxy for risk, or, more precisely, for the standard deviation of the gross margin distribution. By taking the square and the cube, we obtain the variance and the skewness of the gross margin distribution. We then regress the set of inputs on them to obtain the impact of each input on the variance and skewness. As Antle (Antle, 1983), we use a Feasible General Least Square estimator (FGLS). He shows that this method of moment allows estimating in a flexible way the interaction between the set of inputs on the different moment of the output distribution without imposing any cross-moment restriction on the sign of the effect.

The second challenge is the choice of the functional form of the profit function. All results depend on it. As several authors (Antle, 1983, Kumbhakar and Tveterås, 2003, Groom et al., 2008), we use the quadratic form: the gross margin is regressed on the first degree, square and interaction of each explanatory variable. The quadratic form might be interpreted as a second order approximation to an unknown functional form (Greene, 2003). The drawback of the quadratic form is that the number of parameters grows tremendously with the number of variables raising multicollinearity issues.

Once we have obtained the estimates, $\widehat{\beta},$ for the three moments of the distribution, we compute the marginal impact of each variable on the moments of profits:

$$\frac{\partial \mu_{1j}}{\partial x_{kj}} = \frac{\partial E[y|X,Z,\gamma]}{\partial x_{kj}} = \widehat{\beta}_k + 2\widehat{\beta}_{kk} X_{kj} + \sum_{z=1}^{Z} \widehat{\beta}_{kz} X_{zj}$$

$$\frac{\partial \mu_{ij}}{\partial x_{kj}} = \frac{\partial E[\hat{\mathbf{u}}^i|X,Z,\gamma]}{\partial x_{kj}} = \widehat{\beta}_k + 2\widehat{\beta}_{kk} X_{kj} + \sum_{z=1}^{Z} \widehat{\beta}_{kz} X_{zj}$$

Where $i > 1$, $j = 1, \dots N$ denotes the j-th farmer and $z = 1, \dots, Z$ denotes each input except the one from which the derivation is made. We have here completed the first part of the model: we have obtained for each farmer the marginal effect of each input on the three first moment of the distribution of profit.

The second part of the model consists in assembling the system of FOC and estimating it with a three stages least square estimator. Once we obtain consistent estimates, we can then compute the coefficient of absolute risk aversion and the coefficient of downside risk aversion. We impose as Groom et al. (Groom et al., 2008) the constraint that farmers exhibit the same level of risk aversion across the whole range of input choices.

The last step of the model is to draw the link between risk aversion and the participation to REPS. As Franklin et al. (Franklin et al., 2006), we use the relative risk premium as a proxy for the level of risk aversion:

$$RR = \left(\frac{1}{2}\mu_{2k}AP - \frac{1}{6}\mu_{3k}DS\right) \Big/ _{Y}$$

The relative risk premium is then used along a set of explicative variable to estimate the probability of joining REPS.

To sum-up, the estimation strategy has 5 steps spread out on the two parts of the model:

1st part: *the goal is to obtain the marginal effect of the inputs on the profit distribution*

1) To estimate with a fixed effect estimator the effect of each input on the conditional expectation of gross margin;
2) To estimate with a fixed effect estimator the effect of each input on the conditional variance and skewness of gross margin using respectively the square and the cube of the residual of the first regression;
3) To use the three sets of estimates to compute for each farmer the marginal effect (ME) of each input on the mean, variance and skewness of the distribution of his profit;

2nd part: *the goal is to obtain the estimate of risk preferences*

1) To construct the system of first order condition (FOC) by using the ME
2) To use the estimates of the FOC to compute the coefficient of absolute risk aversion and downside risk aversion

Lastly we use the relative risk aversion to estimate the impact of risk preferences on the level of participation to REPS.

DATA

We start by describing shortly our dataset and the Irish dairy sector before presenting and motivating the variables we used in our model. Our dataset is the National Farm Survey (NFS) on the period 1995 to 2009. It is collected by Teagasc, a semi-state research centre of the Republic of Ireland, and it feeds the European Farm

Accountancy Data Network (FADN). The NFS is an annual survey of approximately 1200 farms (average stay in the survey of 5 years). Farming activities are divided in 6 types in the NFS. We focus on the specialist dairy farms (the FADN code is 411). Their number oscillates between 205 and 348 per year. They are mostly located in the South West region (Cork and Kerry, 39%), in the Border region (Cavan, Donegal, Leitrim, Louth, Monaghan, Sligo, 15%), in the South East region (Carlow, Kilkenny, Waterford, Wexford, 14%) and in the Mid-West region (Clare, Limerick, Tipperary, 14%).

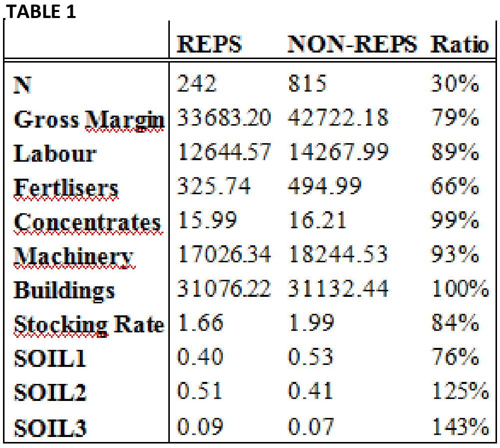
The dairy sector is the second biggest sector of the Irish agriculture. As it counts the biggest ratio of full-time farmers (48% in 2009, Outlook 2010) and has been mostly managed by market mechanisms, dairy producers are more likely to behave as profit maximizers compared with other sectors where more “hobby” farmers are active. The Irish dairy industry is mostly grass-based. The production is therefore closely linked to the cycle of seasons through the level of precipitation and temperature. Therefore, erratic rain presents a significant production risk as well as temperature favoring the growth of parasites. Furthermore, milk price have been very volatile during the last decade.

We present now the variables used in our model. We use as dependent variable the market gross margin and as explanatory variables the stocking rate, labor, investment in machinery, investment in buildings, fertilizers’ uses and feed concentrates’ use. The idea is to focus only on choice variables in order to better model the behavior of the farmers. Furthermore, we don’t include the soil quality as the use of fixed effect factored out time constant variables.

The gross margin is the gross output (the sum of the total milk production, the value of dropped calves, the replacement cost of the dairy herd, the slaughter premium, the dairy herd subsidies and the green pound compensation) minus the direct cost (dairy total feed, and miscellaneous cost such as veterinary cost, milk quota lease etc.) (Aksana Chyzheuskaya et al. forthcoming). We take out the subsidies (slaughter premium, dairy herd subsidies and green pound compensation) to obtain the market gross margin. Despite the fact that we selected only specialist dairy producers, other goods might be produced and sold by the farm. So we need to control for this possibility by weighting each input by an allocation factor computed as the ratio of dairy gross output to crop and livestock gross output. If the ratio is bigger than 1, it is set to 1 and if it is smaller than zero it is set to zero. Lastly the measure is weighted by the consumer price index in order to control for inflation.

Table 1 (table 1) presents summary statistics over the whole period (1995-2009) according to the participation to REPS. We see that slightly less than a third of the sample is part of the scheme, that REPS farmers have in average a gross margin 21% smaller than their counterparts despite working only 11 % less. REPS farmers have therefore a proportionally smaller return on labour invested in traditional farming activities. We also see that they have a smaller stocking rate, which is as expected as REPS impose a limitation on the stocking rate. Lastly, we see that the participation rate increases as the quality of the soil decrease. This might be explained by the higher cost necessary to turn a bad soil in productive pasture: the opportunity cost of joining REPS is smaller (bigger) on soil of poor (high) quality.

TABLE 1



	REPS	NON-REPS	Ratio
N	242	815	30%
Gross Margin	33683.20	42722.18	79%
Labour	12644.57	14267.99	89%
Fertlisers	325.74	494.99	66%
Concentrates	15.99	16.21	99%
Machinery	17026.34	18244.53	93%
Buildings	31076.22	31132.44	100%
Stocking Rate	1.66	1.99	84%
SOIL1	0.40	0.53	76%
SOIL2	0.51	0.41	125%
SOIL3	0.09	0.07	143%

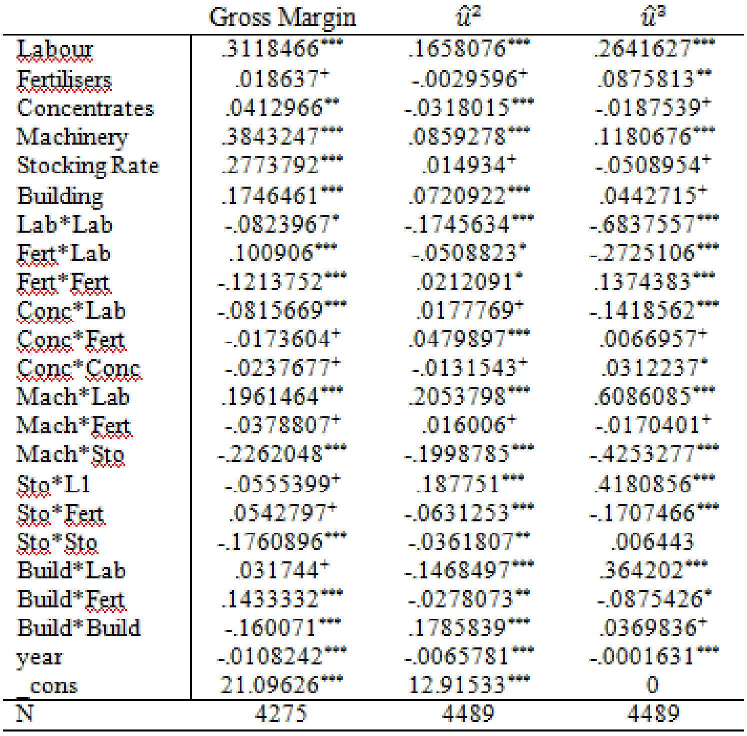
Sources: NFS

RESULTS

As expected, the results were sensitive to the form of the production function and to the variables chosen in the estimation of the system of FOC. This is the reason why we opted for a very flexible functional form for the production function and that we have chosen to present a set of results for the FOC estimations. As we will see, although the estimates of risk preferences are variables, the general picture stays the same.

One of the main concerns in using a quadratic function is the presence of multicollinearity between the explicative variables. We obtain an average VIF of 1.57 and a condition number of 15.3. However, the level rises as soon as we include the interaction variables and the squares. We have tested different specification form taking out subsequently several interactions and square variables and demeaning the variable to get rid of unobservable individual fixed effects. Despite the issue of collinearity, the results have proven fairly stable. Therefore we have decided to keep all terms in the regressions. As Groom et al.(Groom et al., 2008) we normalize all the variable by their standard deviation. Their amplitude as shown in table 2 is therefore not very indicative, however, we see that the level of statistical significance is satisfactory. The next step was to derive the marginal effect of each variable for each farmer.

TABLE 2



	Gross Margin	$\hat{u}^2$	$\hat{u}^3$
Labour	.3118466***	.1658076***	.2641627***
Fertilisers	.018637^{+}	-.0029596^{+}	.0875813**
Concentrates	.0412966**	-.0318015***	-.0187539^{+}
Machinery	.3843247***	.0859278***	.1180676***
Stocking Rate	.2773792***	.014934^{+}	-.0508954^{+}
Building	.1746461***	.0720922***	.0442715^{+}
Lab*Lab	-.0823967*	-.1745634***	-.6837557***
Fert*Lab	.100906***	-.0508823*	-.2725106***
Fert*Fert	-.1213752***	.0212091*	.1374383***
Conc*Lab	-.0815669***	.0177769^{+}	-.1418562***
Conc*Fert	-.0173604^{+}	.0479897***	.0066957^{+}
Conc*Conc	-.0237677^{+}	-.0131543^{+}	.0312237*
Mach*Lab	.1961464***	.2053798***	.6086085***
Mach*Fert	-.0378807^{+}	.016006^{+}	-.0170401^{+}
Mach*Sto	-.2262048***	-.1998785***	-.4253277***
Sto*L1	-.0555399^{+}	.187751***	.4180856***
Sto*Fert	.0542797^{+}	-.0631253***	-.1707466***
Sto*Sto	-.1760896***	-.0361807**	.006443
Build*Lab	.031744^{+}	-.1468497***	.364202***
Build*Fert	.1433332***	-.0278073**	-.0875426*
Build*Build	-.160071***	.1785839***	.0369836^{+}
year	-.0108242***	-.0065781***	-.0001631***
_cons	21.09626***	12.91533***	0
N	4275	4489	4489

We then estimated the system of FOC with a 3SLS estimator. This allows us computing the coefficient of absolute risk aversion and of downside risk. For the estimation of the FOC, we choose 4 inputs which are variables in the short terms and not exposed to budget constraint: labor, fertilizers, concentrate and stocking rate. We show on table 3 the results for different combination of the system of FOC. Although the estimates vary, a clear and general picture emerges: farmers exhibits risk aversion with an average coefficient of absolute risk aversion of 2.23 and of downside risk aversion of 3.07. We then use this estimates to compute the relative risk premium. On average, the risk premium is 16%.

The estimates of the coefficient of absolute risk aversion are in the upper bound of the literature, but the estimates of risk premium are well in line. Indeed, Love and Buccola (Love and Buccola, 1991) obtain estimates of AP between 0.016 and 0.538 in three Iowa counties (1964-1969). Ben Groom et al (Groom et al., 2008) finds for Cypriot cereals and vegetable producers respectively a AP of 0.34 and 0.0726, a DS of - 0.0884 (not significant) and 0.29 and a RP of 17% and 22%. Kumbhakar and Tveteras (Kumbhakar and Tveterås, 2003) find an average AP of 0.4, DS of 0.46 and RP of 18% among Norwegian salmon farmers. The same authors (2009) find an average risk premium of 5.22% among Norwegian salmon farmers and 3% among Philippine rice farmers (2010). Koundouri et al. (Koundouri et al., 2009) show that Finnish farmers become actually risk lover post EU accession due to the generous CAP subsidies. Their AP coefficients drop at the sample average from 0.2 to value close to -1 and the relative risk premium become negative.

We then regress a dummy variable for the participation to REPS on a set of explicative variables and the estimated relative risk premium. In order to control for the fact that the design of the policy makes REPS proportionally more profitable for smaller farmers, we control for the size of the exploitation and for the level of gross margin. Furthermore, we included stocking rate and fertilizers use as REPS restrict the use of both inputs. As expected, all the explicative variables except the relative risk premiums have a negative impact on REPS participation. We see on table 3 that a 1% increase of relative risk premium leads on average to a 0.4% increase in the

TABLE 3

Antle Model				**Probit Model**	
Variables in the FOC	**Absolute Risk Aversion**	**Downside Risk Aversion**	**Relative Risk Premium**	**Relative Risk Premium-REPS ***	**p-value**
L1-Fert	2.99	6.05	19%	0.4%	0.0013
L1-Fert-Conc	3.31	5.21	23%	0.4%	0.0016
L1-Fert-Sto	1.95	3.62	13%	0.6%	0.0014
L1-Fert-Conc-Sto	2.49	3.84	17%	0.5%	0.0017
Fert-Conc-Sto	1.78	2.41	13%	0.7%	0.0021
Fert-Sto	1.22	-3.66	16%	0.0%	0.8001
L1-Sto	1.89	4.03	12%	0.6%	0.0014
Average	2.23	3.07	16%	0.4%	

* Marginal Effect of an increase in risk aversion on the probability of joining REPS

probability of joining the scheme (most estimates are significant at the 0.05 level). We can therefore confirm our hypothesis that the willingness to pay for risk management mechanism is a strong determinant of the participation to REPS. Therefore, we can conclude to the existence of a beneficial dynamic between reforms of the pillar I of the CAP and the *uptake* of agri-environmental policies similar to REPS pursued under pillar II.

However, it is not clear what will be the impact of an increase in risk on the *efficiency* of such policies. Indeed, several empirical studies have shown that smaller farmers are more risk averse than bigger one (Binswanger, 1980, Chavas and Holt, 1996, Rosenzweig and Binswanger, 1993). If it is also the case in Ireland, smaller farmers would derive more utility in securing a constant source of income from REPS. Therefore, an increase in risk could lead to an increase in the ratio of small farmers taking part to voluntary agri-environmental policies. This could lead to an increase in the administrative and monitoring costs of running such policies while decreasing their marginal impact on the environment. At one extreme, we could even imagine that the market condition would drive out of business most small farmers, leaving only big farmers not interested in using REPS as risk management solution.

Lastly, the link between REPS and risk aversion raises a further issue: the possibility of a substitution effect between risk management tool and agro-environmental scheme similar to REPS. The development of a “risk management toolkit” comprising “income stabilization tools, […] insurance instruments and mutual funds” encouraged by the European Commission (European, Commission) could indeed satisfy the demand for income smoothing actually fulfilled by REPS and similar schemes. Even without the support of the public sector, the high demand for risk management tool (on average up to 16% of average income in 2009 following our estimation) is likely to trigger their emergence. Therefore, further research needs to address the optimal design of voluntary agri-environmental policies in the presence of alternative risk management tools.

CONCLUSION

Our estimations show that at the sample average, farmers in 2009 would have been ready to pay on average €5140 per year to get rid of all risk. This might give a rough approximation of the willingness to pay for risk management mechanisms such as yield and income insurances, forward contract and futures. Furthermore, our analysis confirms the hypothesis that the attractiveness of the Rural Environment Protection Scheme (REPS) depends greatly on its ability to smooth income over time. On average, a 1% increase in a farmer's relative risk premium increases by 0.4% his probability to join REPS. As the next reforms of the pillar I of the Common Agriculture Policy (phasing out of the quota in 2015 and the likely lowering of market support in 2013) are likely to increase farmers' exposure to risk, we can conclude to a positive dynamic between reforms of pillar I and the uptake of the voluntary agri-environmental scheme of pillar II. However, as some new risk management solutions such as forward contracts and insurances are likely to emerge in the meantime, further studies need to address the possibility of a substitution effect between new risk management tools and voluntary agri-environmental environmental policies.

Appendix A: Derivation of the model of Antle

The producer is assumed to maximize the expected utility of profit:

$$\max_{X} \; EU(\pi) = \max_{X} \int U[pf(\varepsilon, X) - w'X] \, dG$$

where $G(x, z, \gamma | \bar{x}, \bar{z}, \theta)$ is the joint distribution of the variable input, X , fixed input, Z , and risk attitude, γ . We don’t assume any particular functional form for this distribution.

Assuming that the profit function is bounded on a real integral, the moments of the profit function exist and uniquely determine the profit distribution (Rao, 1973, p.105). The distribution of expected profit for each farmer can be therefore characterized by the mean ($\mu_1(\dots)$) of the profit distribution, its variance ($\mu_2(\dots)$), its skewness ($\mu_3(\dots)$) and the other higher moments ($\mu_i(\dots); i > 3$). In brief, the expected utility is expressed as a function of the moments of the profit function:

$$EU = U[\mu_1(\dots), \dots, \mu_m(\dots)] = U[\boldsymbol{\mu}^m]$$

Where μ^m is the vector of the profit’s moments. The first order conditions (FOC) of the maximization are expressed as the sum of the partial derivatives of the utility of the profit distribution:

$$\sum_{i=1}^{m} \left(\frac{\partial U[\mu^m]}{\partial \mu_i} \frac{\partial \mu_i}{\partial x_k} \right) = 0$$

By rearranging, we get:

$$\frac{\partial \mu_1}{\partial x_k} = - \frac{\frac{\partial U[\mu^m]}{\partial \mu_2}}{\frac{\partial U[\mu^m]}{\partial \mu_1}} \frac{\partial \mu_2}{\partial x_k} - \frac{\frac{\partial U[\mu^m]}{\partial \mu_3}}{\frac{\partial U[\mu^m]}{\partial \mu_1}} \frac{\partial \mu_3}{\partial x_k} - \frac{\frac{\partial U[\mu^m]}{\partial \mu_4}}{\frac{\partial U[\mu^m]}{\partial \mu_1}} \frac{\partial \mu_4}{\partial x_k} \dots$$

Now, we need to relate this expression to the risk preferences defined in terms of coefficient of Arrow-Pratt absolute risk aversion (AP) (Pratt, 1964) and downside risk aversion (DS)(Kimball, 1990). First, we approximate the utility function by a Taylor series expansion:

$$EU[\pi] = U[\mu^m] \approx U(\mu_1) + \sum_{i=2}^{\infty} U^i[\mu_1] \mu_i \frac{1}{i!}$$

$$\frac{\partial EU}{\partial \mu_i} \approx U^i[\mu_1]\frac{1}{i!} \qquad i > 1 \qquad\qquad \frac{\partial EU}{\partial \mu_1} \approx EU^1[\mu_1] = U^1$$

where $U^i(\ldots)$ denotes the *i-th* derivatives of $U(\ldots)$. Here, it should be noted that the equality of EU^1 with U^1 works for a third order approximation (our cases in the coming estimation) and only when the marginal utility function is linear. Otherwise, $EU^1 \gtreqless U^1$ as $U^3 \gtreqless 0$. We can write:

$$\frac{\dfrac{\partial U[\mu^m]}{\partial \mu_i}}{\dfrac{\partial U[\mu^m]}{\partial \mu_1}} = \frac{U^i[\mu_1]}{U^1}\frac{1}{i!}$$

And rewrite the FOC as:

$$\frac{\partial \mu_1}{\partial x_k} = \vartheta_2 \frac{\partial \mu_2}{\partial x_k} + \vartheta_3 \frac{\partial \mu_3}{\partial x_k} - \cdots \qquad where\ \vartheta_i = -\frac{\partial U[\mu^m]}{\partial \mu_i} \Big/ \frac{\partial U[\mu^m]}{\partial \mu_1}$$

As the Pratt coefficient of absolute risk aversion and the coefficient of downside risk aversion are:

$$AP = -\frac{U^2[\mu_1]}{U^1}$$

$$DS = \frac{U^3[\mu_1]}{U^1}$$

We might finally rewrite the FOC as:

$$\frac{\partial \mu_1}{\partial x_k} = \left(\frac{1}{2}\right) AP \frac{\partial \mu_2}{\partial x_k} + \left(-\frac{1}{6}\right) DS \frac{\partial \mu_3}{\partial x_k} + u$$

Appendix B: Derivation of the Risk Premium

We replicate here closely the derivation of the risk premium as given by Chavas (Chavas 2004). The risk premium under the expected utility model might be defined by:

$$EU(w+x) = U(w+E(x)-R)$$

where w is the initial wealth x is a random variable corresponding to the future and unknown revenue (e.g. profit at the end of the year) and R is the risk premium. Now, taking a third order Taylor series expansion (instead of a 2nd as in Chavas) of $U(w+x)$:

$$U(w+x) \approx U\big(w+E(x)\big) + U'\big(x-E(x)\big) + 0.5U''\big(x-E(x)\big)^2 \\ + \frac{1}{6}U'''\big(x-E(x)\big)^3$$

And taking the expectation:

$$EU(w+x) \approx EU(w+E(x)) + U'E(x-E(x)) + 0.5U''E(x-E(x))^2 + \frac{1}{6}U'''E(x-E(x))^3$$

$$\approx EU\big(w+E(x)\big) + 0.5U''^{\mu^2} + \frac{1}{6}U'''\mu^3$$

Now, we take a second order Taylor series expansion of $U(w+E(x)-R)$ with respect to R in the neighbourhood of $(w+E(x)-R)$:

$$U(w+E(x)-R) \approx U(w+E(x)) - U'R$$

We substitute both results to obtain:

$$U(w+E(x)) + 0.5U''\mu^2 + \frac{1}{6}U'''\mu^3 = U(w+E(x)) - U'R$$

Rearranging the equation:

$$U(w+E(x)) - U(w+E(x)) + 0.5U''\mu^2 + \frac{1}{6}U'''\mu^3 = -U'R$$

$$0.5U''\mu^2 + \frac{1}{6}U'''\mu^3 = -U'R$$

$$R = -0.5\frac{U''}{U'\mu^2} - \frac{1}{6}\frac{U'''}{U'\mu^3}$$

$$R = \frac{1}{2}\mu_{2k}AP - \frac{1}{6}\mu_{3k}DS$$

If one derives as Chavas (2004) $U(w + x)$ from a second order Taylor series approximation, the risk premium is simply:

$$R = \frac{1}{2}\mu_{2k}AP$$

The risk premium might be interpreted as the willingness to be pay to get rid of the risk. This therefore the willingness to be insured (Chavas, 2004). We see that a rise (decrease) of the variance or of the coefficient of absolute risk aversion will rise (decrease) the risk premium. Furthermore, a rise (decrease) in the exposure to downside risk ($\Delta\mu_1 3k < 0$) or a rise (decrease) of downside risk aversion ($\Delta DS > 0$) will increase (decrease) the risk premium.

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