Adoption of environmentally-friendly agricultural practices in the presence of background risk: experimental evidence

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M. Lefebvre and E. Midler formulated the original question. The experiment was designed by M. Lefebvre, E. Midler and S. Blondel and programmed by B. Goujon in Limesurvey. M. Lefebvre and E. Midler performed data analysis and wrote the first version of the manuscript. All authors provided feedback on the manuscript. M. Lefebvre was responsible for overall coordination.

Abstract: The integration of environmental objectives into the CAP was made through conditioning CAP payment on the adoption of environmentally friendly farming practices. By covering the extra costs and risk of green practices compare to conventional farming, these payments can favor adoption of green practices. However, while individuals can choose whether to engage in more risky farming practices or not, there are also some background risks farmers are exposed to without (or with very limited) possibility of control, i.e., risks that are non-diversifiable or non-insurable. Little is known on the impact of background risk on the adoption of green practices and on the efficiency of CAP payments to foster this adoption. In this article, we analyse the impact of background risk on decisions to adopt environmentally-friendly practices. Second, we evaluate how incentive payments, such as CAP green payment and agri-environmental schemes, can influence adoption decisions in such a risky environment. To do so, we conducted an on-line framed field experiment with 125 French agricultural students based on a public good game. As expected, risks linked to green farming practices discourage farmers from adopting them. Background risk is also detrimental to the adoption of green farming, both for risky environmentally friendly practices are risky and non-risky ones. The incentive payment has a positive impact on adoption. However, when farmers face both types of risks, the incentive payment is significantly less efficient in encouraging the adoption of environmentally friendly practices. Results shed light on the current tension between greening the CAP and strengthening CAP support to farm risk management.

JEL codes: C93, D81, Q18, Q12

Keywords: environmentally-friendly agricultural practices, agricultural policy, risk management, background risk, field experiment, on-line experiment

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1. Introduction

Among the prime challenges facing EU agriculture and its common policy post 2020, one is to go further into the adoption of environmentally-friendly agricultural practices and sustainable land management. This requires discussion on how to incentivize farmers to manage the environment better, in an efficient and cost-effective way.

There is a large body of literature in agricultural economics on the determinants of environmentally friendly farming practices adoption. Two main barriers to adoption are generally mentioned: First, farmers support private costs to implement environmentally friendly practices, but the ecosystem services generated benefit to all, therefore leading to the well-known problem of under-provision of the public good. Second, environmentally friendly farming practices such as reduced tillage, reduction of pesticide use or longer rotation are perceived as risk increasing. Because farmers are risk adverse, this reduces the adoption of agro-environmental practices. Acs et al. (2009) have shown that no conversion to organic farming takes place when relative risk aversion is above 3, while partial conversion takes place when relative risk aversion ranges between 0.5 and 2.0.

In line with the first argument, it is often thought that CAP payments could favor adoption of environmentally-friendly practices by covering the extra costs and the risk premium associated with the adoption of risky environmentally-friendly practices compare to conventional farming. But farmers face uncertainty about the economic consequences of their actions due to their limited ability to predict things such as weather, prices and biological responses to different farming practices.[1] Another challenge for CAP reform is answering to farmers' concerns about the increasing uncertainty they face. Risk is widely seen as an issue of critical importance to farmers' decision making and to policies affecting those decisions.

Farmers can choose to avoid the risk associated with environmentally-friendly practices by not engaging in those practices, but there are other risks farmers are exposed to without (or with very limited) possibility of control, because those risks that are nondiversifiable or noninsurable. For example, agricultural insurers do not offer frost insurance to all wine growers. As mentioned by Beaud and Willinger (2014) "some risks remain inevitably in the background (…) there is no risk-free situation for individuals". Taking into account the background risk to which individuals are exposed can significantly improve our understanding of risk-taking behavior in many contexts, including the decision to adopt risky environmentally-friendly practices.

The objective of the paper are twofold. First, we analyse the impact of background risk on decisions to adopt environmentally-friendly practices. Second, we evaluate how incentive payments, such as those proposed under the first and second pilars of the CAP: the green payment and agri-environmental schemes, can influence adoption decisions in such a risky environment

1 We use the terms 'risk' and 'uncertainty' interchangeably to mean that they are random variables in the decision problems face by farmers.

To answer the above questions, we conducted a framed field experiment with 125 French agricultural students based on a public good game. We chose a public good game to capture the ecosystem services provided by environmentally-friendly practices, such as pollination services or biocontrol, providing public good benefits for the community. Subjects decide how much of their land they would like to farm according to conventional or to environmentally-friendly practices. Green practices provide ecosystem services but entail an opportunity cost for farmers and can bring riskier private returns.

While previous studies have analyzed the impact of environmental risk and strategic uncertainty on public good provision (Dickinson 1998, Gangadharan and Nemes 2009, Levati, Morone, and Fiore 2009, Levati and Morone 2013), none of them have studied the impact of background risk. Our contribution is twofold: First, we introduce background risk in a public good game. Second the game is contextualized in order to capture the context of European agriculture and the subject pool consists of stakeholders (students in agriculture).

The next section provides background information the use of experimental approach for agricultural policy evaluation, on the impact of risk on public good provision, and the impact of a background risk on risk taking behaviours. Section 3 describes the design of the experiments, and section 4 the theoretical predictions. Results are presented and discussed in Section 5. Finally, the conclusions are presented in the last section.

2. Conceptual background

The use of experimental approach for agricultural policy evaluation

Methodologies for policy evaluation have made several major advances in the past decades and economic experiments are at the forefront of these recent methodological developments, in particular for agricultural policy evaluation (Colen et al. (2016)). First, greater attention is paid to identifying cause-effect relationships of policies, by building an experimental situation or by identifying a quasi-experimental situation for which outcomes can be compared to a proper counterfactual. In an economic experiment, data that are generated in a controlled setting, with a randomized assignment of participants to treatment and control groups. This allows for a clearer identification of impact and causality, and results which are potentially replicable in different contexts or with different types of participants. Moreover, to ensure that participants in the experiment reveal their true preferences, they often receive financial incentives related to what their economic gains could have been in an equivalent real-life setting.

Second, behavioral studies have highlighted the need to account for elements of the decision context beyond the simple profit maximization assumption, in order to predict economic agents' responses to different policy instruments and to design efficient and cost-effective policies. Other methodologies such as farm level mathematical programming models, have also gone beyond profit maximization by relying on complex utility functions, allowing to account for farmers' risk aversion. But a critical assessment of the literature performed by Pannell, Malcolm and Kingwell reveals that the aspects of agricultural risk most commonly modelled often are issues of secondary importance in determining how farms are managed. In particular, "in many situations the net benefits of using modelling resources to represent risk aversion are less that the net benefits of using the resources to improve other aspects of the model." Moreover, those models ignore background risk. For example, in their model aiming at understanding low adoption of agri-environmental measures, Ridier et al assume that yield risk due to climate variability is the only source of risk. They voluntarily ignore market risk in order to focus on the risk of implementing new farming practices. As a result, experimental evidence, where simplifying assumption are not necessary since behaviors are observed, are an interesting complementary evaluation tool.

Relevant literature on the impact of background and foreground risk on farmers' decisions

Experiments allow to disentangle the impact of several explanatory factors of low adoption: the magnitude of risk associated with the practice, the risk aversion of the farmer, the possibility to free-ride on others' adoption by enjoying collective benefits without bearing the private costs.

In the experimental literature applied to environmental issues, several authors have analyzed whether individuals contribute voluntarily to public goods when the value of the public good is ex ante unknown to potential contributors (Dickinson 1998; Gangadharan et Nemes 2009; Levati, Morone, et Fiore 2009; Levati et Morone 2013). Gangadharan and Nemes (2009) have designed a public good game in the lab to examine how decision makers contribute toward private or public goods when they are exposed to different kinds of risks and uncertainties in the provision of these goods. Environmental uncertainty refers to random external factors that determine which group action is best, while strategic uncertainty concerns other group members' response (Messick., Allison, et Samuelson 1988). Contrarily to previous studies, they kept the strategic uncertainty constant across treatments in order to study properly the effects of environmental uncertainty. They found that risky and uncertain marginal returns from a public good lower contributions significantly.

But Levati and Morone (2013) have shown that this effect depends on the employed parameterization. They have set the minimum marginal per capita return (MPCR) such that contributing to the public good increases efficiency even in the worst state of nature. They found that with contributions in both the risk and the uncertainty treatments are not significantly different from contributions in the control treatment with a sure marginal per capita return (MPCR). They conclude that risk aversion per se cannot cause the significant decline in contributions observed by previous studies in the presence of risk and uncertainty. Rather, they explain the results of previous studies by loss aversion. Brewer and Kramer (1986) and McCusker and Carnevale (1995) have suggested that public goods problems create a loss frame: contributing to a public good entails giving up something, thereby enduring an immediate loss, in order to possibly gain a future benefit.

Theoretical literature has analyzed whether the presence of background risk lead to more or less cautious behavior. Relying on von Neumann and Morgenstern's (1944) expected utility (EU) theory, Gollier and Pratt (1996) have identified the structure of individuals' preferences guaranteeing that an individual behave in a more cautious way if an actuarially neutral background risk is added to his or her initial wealth: the "risk vulnerability". While the risk vulnerability implies decreasing absolute risk aversion (DARA), Quiggin (2003) showed that, for the wide class of risk-averse generalized expected utility preferences that exhibit constant risk aversion, an individual who is exposed to background risk would be willing to take more foreground risk. Because alternative theories have different predictions about the impact of background risk on risk-taking behavior, experiments can help to whether most persons are risk vulnerable or not. Laboratory and field experiments conducted by Harrison et al. (2007), Lusk and Coble (2008), Lee (2008), and Beaud and Willinger (2014) all support the risk vulnerability conjecture: an individual who is exposed to background risk would be willing to take less foreground risk.

Whether background risk decreases contribution to a public good with risky marginal return remains an open question. We have developed

3. Experimental design

The game

Each participant forms part of a group of n players and disposes of L hectares. Participants decide to divide this land L between ‘‘conventional farming” and ‘‘green farming”. Their payoff depends on both their individual contribution to green farming (g_i) and the total area farmed with green practices ($G=\sum_{i=1}^{n} g_i$):

$\pi_i = (b - c_c)(L - g_i) + (b - c_g)g_i + \beta G$ The net benefits from farming depends on the financial yields b minus the costs multiplied by the number of hectares. The financial yields include the price, the yield and the base payment, and are the same for both types of practices. The underlying assumptions are: i) most environmentally friendly practices do not provide access to different market opportunities and prices for the products since they cannot be labeled or certified (contrary to organic farming for instant); ii) There is no evidence on the impact of environmentally-friendly practices on yields and yields variability, notably because yield level has many determinants interacting with each other. For example, Lechenet et al. (2017) showed that using agro-ecological practices in order to reduce pesticide use does not impact production negatively; iii) CAP direct payments (base payment) are unconditional to farm practices.

However, environmentally-friendly practices are assumed to be on average costlier ($c_g > c_c$). Differences in costs are caused mainly by the fact that alternative management strategies can be more labor consuming. For example, it is generally agreed that integrated pest management strategies, such as those based on crop diversification and rotations, are time and information/knowledge intensive, compared to pesticide-based pest management strategy as used in conventional agriculture (Guillou et al. 2013; Lefebvre, Langrell, et Gomez-y-Paloma 2015).

When one unit of land is environmentally-friendly farmed, βG points are earned by each farmer of the group, with β the ‘‘efficiency factor’’ of the green land, corresponding to the ecosystem services associated with the green practices. For example, maintenance of hedges can favour pollination services or biocontrol.

The experiment corresponds to an impure public good game (Narloch, Pascual, et Drucker 2012; Midler et al. 2015). Indeed, contributions to the public good generate collective benefits but also provide private benefits to the player: $b - c_g$.

A profit maximizing farmer will adopt green practices and therefore contribute to the public good only if the extra profits associated with the ecosystem services generated by the green practice adoption are compensating the extra costs of these practices $\beta > c_g - c_c$. If the ecosystem services do not have a sufficient monetary value for the farmers, the adoption of environmentally-friendly practices can be supported by an incentive payment scheme: s per hectare. One can think of the agro-environmental payment of the rural development policy and the green payment in the first pillar of the CAP as two examples of incentive payments conditional to the observance of certain environmental standards or practices. In such case, the payoff function becomes:

$$\pi_i = (b - c_c)(L - g_i) + (b - c_g)g_i + \beta G + s g_i$$

And a profit maximizing farmer will fully adopt green practices if $\beta + s > c_g - c_c$.

Treatments

The two main treatment variables in our experiment are the nature of the risk faced by participants and the presence of the incentive payment to foster adoption of environmentally-friendly practices.

Participants are randomly allocated to one of the four between-subject treatments differing by the nature of the risk. In the control treatment (T1), subjects know the value of the parameters c_g and b. In the other experimental treatments, we introduce risk on these parameters, but they keep the same expected values. Specifically, in the foreground risk treatment (T2), the adoption of environmentally-friendly practices is risky since costs are unknown: subjects are informed that c_g can be either $\overline{c_g}$ or $\underline{c_g}$, each with probability ½. In the treatment with background risk (T3), subjects are informed that the market benefits b can be either $\overline{b}$ or $\underline{b}$, each with probability ½. This background risk captures both production uncertainty on yields, price uncertainty, as well as policy uncertainty, regarding the size of direct payments (Moschini et Hennessy 2001), impacting all the farm land, independently from agricultural practices. In other words, the background risk impacts both the private and the public goods. In T3, there is no foreground risk, therefore assuming that environmentally-friendly practices are not risky. The fourth treatment (T4) corresponds to the realistic situation where farmers face both foreground and background risk.

The incentive payment is a within-subject treatment variable. All participants take two decisions: first without any policy instrument (*s*=0), then with an incentive payment (*s*>0).

The value of the parameters are available in Table 1.

Table 1: Treatments and parameters

Treatments between-subject	L	b	c_c	c_g	β	Nb of participants	No policy scenario	Policy scenario
T1: Control	80	15	4	7	2	26	s=0	s=2
T2: foreground risk	80	15	4	5 or 9	2	29		
T3: Background risk	80	10 or 20	4	7	2	39		
T4: Both risks	80	10 or 2110	4	5 or 9	2	31		

Experimental procedure

The experiment was run on-line in May 2017. Like in survey experiments[2], participants were randomly assigned by the online platform to one of the four treatments, a priori ensuring that the socio-demographic characteristics of the participants were not significantly different across the four groups.

At the beginning of the survey, subjects were invited to read the instructions of the experiment explaining the different parts of the survey and the monetary incentives. In each part of the survey, they answered a quiz which tested their understanding of the instructions. The instructions are available in the supplementary appendix.

[2] « Survey experiments » is a term used by scholars of political behavior to define opinion surveys where respondents are randomly assigned to alternative versions of questionnaire items (Gaines, Kuklinski, et Quirk 2007).

The survey is made of five parts. First, before the public good game, we have run two complementary tasks to elicit risk aversion and social preferences. Risk aversion has been shown to have significant impact on decisions in public good games (Dickinson 1998), as well as in coordination game. Social preferences are also important drivers of contributions in public good games (Fischbacher et Gachter 2010).

The first part of the survey is a lottery-choice task derived from the investment game to capture the sensitivity of subjects to exogenous risk (Gneezy et Potters 1997; Charness et Gneezy 2010). The number of points not invested is used as a relative indicator of risk aversion: the more risk averse the individual, the lower the number of points invested.

In the second part, to measure social preferences, we have used the Social Value Orientation measure (Murphy, Ackermann, et Handgraaf 2011). For this method, subjects are asked to participate in a set of dictator games where they have to share some amounts of money between themselves and another (anonymous) player. These decisions are then used to measure subjects' social preferences: the greater the index obtained, the higher the social preferences of the player. It is then possible to classify them in 4 categories; i) competitive players, who are willing to sacrifice their own payoff to lower the payoff of the other, ii) individualistic players, who just maximize their own payoff, independently of the impact on the other player, iii) pro-social players, who aim at maximizing the joint payoff of both players and iv) altruistic players who are willing to sacrifice their own payoff to improve the payoff of their partner. In our sample, we found 10% of competitive players, 42% of individualistic ones and 47% of pro-social players. This is similar to what have been found in the literature.

No significant differences were observed in risk aversion and social preferences in the four treatment groups, suggesting that random allocation of participants to the different treatments had the desired effect.

The public good game is played in the third and fourth parts of the experiment. As said before, the same game was conducted twice, once without the incentive payment (part 3) and once with it (part 4).

We have chosen a "one-shot" design, which is a departure from the majority of public goods experiments, in which participants make repeated decisions in a single treatment, with earnings feedback provided between rounds. Our main motivation for the one-shot design was to rely on an asynchronous experimental design, because they do not require a large group of subjects to participate at the same time. Moreover, as explained by Goeree et al (2002), the one-shot design allows to mitigate the possibility of reciprocity or strategic attempts to trigger others' reciprocity. Given the focus of the experiment on the impact of risk on the adoption of practices with public good properties, we did not want good or bad experiences with respect to others' contribution to the public good to influence the game.

To prevent prior attitudes and beliefs about the consequences on costs and yields of specific environmentally-friendly practices from influencing subjects' behaviors, we chose not refer to a particular bundle of environmentally-friendly practices and a neutral terminology is used: environmentally-friendly practices are called "the purple farming system", by opposition to the "orange farming system". Subjects are told the purple farming system is more environmentally-friendly, allows to maintain the same financial yield but is costlier.

Before taking their decision, participants could see on tables their individual payoff according to the number of land units allocated to environmental-friendly practices and the additional group payoff due to ecosystem services according to the total number of land units allocated to environmental-friendly practices in their group (see instructions). They were told that their total payoff is the sum of the individual and the additional group payoff. After they entered their decisions, they were asked to indicate their believes on their neighbour's choice.

In the last part, qualitative and quantitative information was collected from the participants using survey questions.

Farmers were informed that their decisions would affect the size of the earnings they would receive. Points earned in each part of the game are summed, and converted at a known fixed rate into euros (200 points=1 euro). A multi-brand gift card was sent to each participant via ordinary mail with a credit corresponding to the winnings in the survey. Final earnings were thus between 9 and 23€, with an average around 16€. It took on average 30 minutes to complete the survey.

Sample

In total, 125 agricultural students took part in the field experiment. While lab experiments with university students remain common, a growing number of experiments involve samples of representative populations, professionals, specialists. Results are mixed with regard to behavioral differences between those and students. The potential reasons to behavioral differences are: the distribution of social preferences (Carpenter et Seki 2011), familiarity of the subject with the topic (Frechette 2011) and self-selection issue. Professionals tend to behave more prosocial than students in lab experiments (Fehr et List 2004; Bellemare et Kröger 2007; Belot, Duch, et Miller 2010). Ferre et al. (2017) is the first study to compare professionals (farm apprentices) with students in a contextualized experiment related to farming. They claim that the experimental context can trigger signals that do matter to the decision-making process of a particular subject. For this reason, we rely on stakeholders and a contextualized experiment.

The participants have on average 20 years old. They are full-time students in agriculture since two years. 54% are male. The following numbers indicate that they are concerned with agriculture and can be considered as stakeholders. 58% of them have farmers in their closest family members (parents, siblings or parental siblings). 44% of them spend more than 30 days a year on a farm. 30% of them declare they will be farmers before their thirties, and 40% do not reject this option. Less than one third of the participants already know they do not want to become farmers in the future.

4. Theoretical predictions

No policy scenario

In the absence of risk (T1), choosing green farming practices instead of conventional ones represents an opportunity cost of $c_g - c_c - \beta = 1$ point per hectare. In addition, the public benefits arising from adopting green practices are uncertain since they depend on the decisions of the other member of the group. Therefore, participants' best private strategy is not to allocate any land units at all to environmentally-friendly practices (g_i=0) and to instead free-ride on others in order to earn the collective benefits. The Nash equilibrium is thus reached when both subjects in the group farm all their land L with conventional practices (g_i=g_j=0). By contrast, the social optimum i.e., where the group's total benefits would be maximized, is reached when both group members allocate all their land units towards the environmentally-friendly farming practices (g_i=g_j=L).

When risk is introduced (T2, T3 and T4), the expected utility of both players remains the same. Thus, the best private strategy of risk neutral participants is still not to allocate any land units at all to environmentally-friendly practices (g_i=0). If all subjects are risk neutral, no difference is expected across treatments. However, risk aversion and risk vulnerability can explain such differences.

$$EU(\pi_i) = EU\left((b - c_c)(L - g_i) + (b - c_g)g_i + \beta G + sg_i\right)$$

Policy scenario

The introduction of the incentive payment s changes the best strategy and thus the Nash equilibrium of the game. In treatment 1 (no risk), choosing g_i=80 becomes the best strategy given that $\beta + s > c_g - c_c$. The incentive therefore implements the social optimum as a Nash equilibrium. As expected payoff are the same in all treatments, this is also the best strategy for risk neutral players in all other treatments.

Hypotheses tested

Following our theoretical predictions, and the experimental observations on the contribution to public good in the presence of risk and the impact of background risk on risk taking behavior, we develop a set of hypotheses to test:

Hypothesis 1: Subjects are less likely to adopt green practices when they are risky (comparison T1-T2 and T1-T4).

Hypothesis 2: Subjects are less likely to adopt green practices in the presence of background risk (comparison T2-T4 and T3-T4).

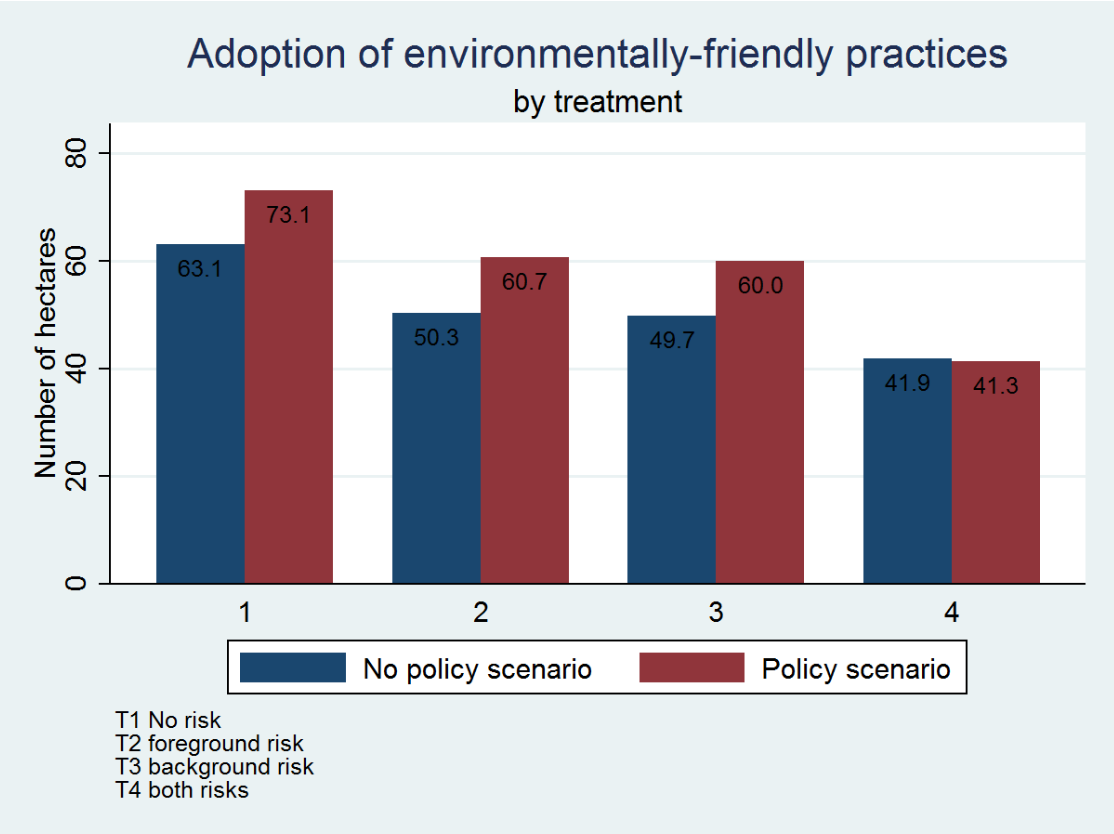
Hypothesis 3: The incentive payment increases adoption of green practices (comparison part 1-part 2)

5. Results and discussion

Data analysis

The decision variable analysed is the number of hectares farmed with environmentally-friendly practices, i.e. the individual contribution to the public good (see figure 1 below).

Figure 1 : Average number of hectares cultivated with environmentally-friendly practices per treatment



First, we examine the differences across treatments using nonparametric tests. To measure the impact of background and foreground risk, we relied on the Wilcoxon rank-sum two-sample test to compare the choices of participants in the four between-subject treatments, in the no policy scenario. Results are shown in table 2 below. In order to analyze the impact of the incentive payment on the adoption of green practices, and the way it might influence it differently depending on the risk contexts, we rely on a Wilcoxon matched pair test to compare the choices of participants without and with incentive payment, and on the results from the econometric model, which includes interactions between the payment variable and the treatment variables. Tests' results are presented in table 3.

Second, we rely on random effect panel tobit regressions as the number of hectares are left-censored at zero and right-censored at 80. We use random effects at the subject level to capture the unobserved heterogeneity between subjects. The variables are described in table 4 and the results are shown in table 5.

Table 2 : Results of Wilcoxon two samples tests, with no policy

	T2	T3	T4
T1	z = 2.181 Prob>|z|=0.0292 **	z = 2.727 Prob>|z|=0.0064 ***	z = 3.178 Prob>|z|=0.0015 ***
T2	**X**	z = 0.142 Prob>|z|=0.8874 -	z = 1.292 Prob>|z|=0.1965 -
T3	X	**X**	z = 1.320 Prob>|z|=0.1870 -

The number of stars indicates the significance level : *** is significant at 1 %, ** is significant at 5 %, * is significant at 10 %, - is not significant.

Table 3 : Average number of hectares farmed with environmentally-friendly practices and results of Wilcoxon matched pair tests

	T1	T2	T3	T4
No policy scenario	63	50	50	42
Policy scenario	73	61	60	41
difference	z = -3.155 Prob>|z|=0.0016 ***	z = -2.611 Prob>|z|=0.0090 ***	z = -2.468 Prob>|z|=0.0136 **	z = -0.444 Prob>|z|=0.6573 -

Table 4: Summary of the dependant variables used in the models

Name of the variable	Description
payment	1 if there is an incentive payment, 0 otherwise
px TX	Interaction term between treatment variables *TX* and *payment*
SVO_pro	1 if the subject is prosocial according to the social value orientation measure, 0 otherwise
px SVO_pro	Interaction term between the SVO measure and *payment*
RA_higher	1 if the subject invested less points in the risky asset than the median (300 points) in the risk aversion elicitation task, 0 otherwise
RA_higher xTX	Interaction term between variables the risk aversion and the treatment variables
femme	1 if the subject is a woman, 0 otherwise
familleagri	1 if the suvject has farmers in his/her family (father, mother, siblings, uncle, ant), 0 otherwise
joursferme_D60	1 if the subject spends more than 60 days per year on a farm, 0 otherwise
install_AB	1 if the subject plans to become an organic farmer, 0 otherwise
install_nonAB	1 if the subject plans to become a conventional farmer, 0 otherwise
Impact_envt_trespositif	1 if the subject answered “very positive” to the question “Do you think agricultural practices have a positive or negative impact on the environment? », 0 if the subject answered “positive”, “negative” or “very negative”

Table 5. Results of the regression models (coefficient and statistical significance, random effects panel tobit)

```
Random-effects tobit regression                 Number of obs      =       250
Group variable: id                              Number of groups   =       125

Random effects u_i ~ Gaussian                   Obs per group:
                                                              min =         2
                                                              avg =       2.0
                                                              max =         2

Integration method: mvaghermite                 Integration pts.   =        12

                                                Wald chi2(19)      =     65.45
Log likelihood  = -822.62809                    Prob > chi2        =    0.0000
```

decisionPG	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
T2	-18.07546	9.845733	-1.84	0.066	-37.37274	1.221822
T3	-22.86651	9.081236	-2.52	0.012	-40.66541	-5.067618
T4	-33.45285	9.997152	-3.35	0.001	-53.04691	-13.85879
payment	29.25597	8.357868	3.50	0.000	12.87485	45.63709
pxT2	-9.584305	10.15239	-0.94	0.345	-29.48263	10.31402
pxT3	-7.649799	9.590277	-0.80	0.425	-26.4464	11.1468
pxT4	-23.96048	9.905003	-2.42	0.016	-43.37393	-4.547032
SVO_pro	12.93622	5.783328	2.24	0.025	1.601109	24.27134
pxSVO_pro	-10.73768	6.225198	-1.72	0.085	-22.93885	1.463483
RA_higher	-3.784996	14.70242	-0.26	0.797	-32.6012	25.03121
RA_higherxT2	-.018554	19.03548	-0.00	0.999	-37.32741	37.2903
RA_higherxT3	14.66021	17.88426	0.82	0.412	-20.39229	49.7127
RA_higherxT4	7.681715	17.754	0.43	0.665	-27.11548	42.47891
femme	-8.613832	5.449267	-1.58	0.114	-19.2942	2.066535
familleagri	.0244528	6.146975	0.00	0.997	-12.0234	12.0723
joursferme_D60	6.590657	7.295763	0.90	0.366	-7.708775	20.89009
install_AB	7.872475	9.048769	0.87	0.384	-9.862786	25.60774
install_nonAB	-4.953655	7.880151	-0.63	0.530	-20.39847	10.49116
impact_envt_trespositif	-43.47281	16.83315	-2.58	0.010	-76.46518	-10.48045
_cons	70.81805	9.066744	7.81	0.000	53.04756	88.58854
/sigma_u	20.74135	2.700428	7.68	0.000	15.44861	26.03409
/sigma_e	22.17365	1.76317	12.58	0.000	18.7179	25.6294
rho	.4666618	.0822735			.3123208	.6262564

The number of stars indicates the significance level : *** is significant at 1 %, ** is significant at 5 %, * is significant at 10 %.

Impact of risk on the adoption of green practices

Result 1: *Subjects are less likely to adopt green practices when they are risky*

Subjects in the treatments with green practices risk (T2 and T4) allocated less hectares to the environmentally-friendly practices than those in the treatment without risk (T1). This is confirmed by the results from the non-parametric tests (table 2), which are significant at the 1% level for T4 and 5% level for T2.

Result 2: *Players are less likely to adopt green practices in the presence of background risk*

Subjects allocated less hectares to the environmentally-friendly practices in the treatments with foreground and background risks (T4) than in the treatment with only foreground risk (T2). Subjects also allocated less hectares to the environmentally-friendly practices in the treatments with only background risk (T3). This is confirmed by the results from the non-parametric tests. This suggests that subjects behave in a more cautious way in the presence of background risk, as stated by the risk vulnerability conjecture. When environmentally-friendly practices are not risky (T3), subjects are still reluctant to engage in such practices because they are costlier. This is coherent with expected utility theory assuming DARA preferences (decreasing absolute risk aversion). Given that environmentally-friendly practices have higher costs and decrease income, subjects are more risk averse and less likely to adopt these practices in the presence of background risk (T3) than without risk (T1).

Impact of the incentive payment

Hypothesis 3: The incentive payment increases adoption of green practices (comparison part 1-part 2)

In all treatments but T4, subjects allocated significantly more hectares to the environmentally-friendly practices in the policy scenario than in the absence of incentive payment (table 3). However, the average number of hectares allocated to green farming is lower than the Nash equilibrium: risk neutral subjects are expected to farm all their land with environmentally-friendly practices in the policy scenario. This confirm that subjects are risk neutral. In the policy scenario, while 73% of the subjects choose to farm all their land with green practices in T1, this number drops in the presence of foreground risk (38%), background risk (44%) and both risks (23%).

The absence of significant impact of the incentive payment in the treatment with both risks suggests that a fixed subsidy is not sufficient to encourage adoption of risky environmentally-friendly practices in the presence of background risk.

Impact of risk aversion and pro-social behaviour

Risk aversion as elicited in the portfolio investment game does not seem to explain decisions to farm with risky environmentally-friendly practices (table 5). This absence of impact of elicited risk is observed in all risk contexts. It suggests that the risk elicitation task we have chosen may not be reflect behaviours in other domains (Soane et Chmiel 2005).

However, social value-orientation plays a significant role. Pro-social individuals (those who have attempted to maximize the joint payoff of both players in the set of dictator games) are more willing to farm with environmentally-friendly practices than the others. As a result, the payment is less efficient to influence their decisions. We observe a negative and significant impact of the interaction term between payment and pro-social individuals, suggesting that the payment is more effective in changing non pro-social individuals behaviors, which is confirming results from the literature (Midler et al. 2015).

6. Conclusions

As expected, risks linked to green farming practices discourage farmers from adopting them. Background risk is also detrimental to the adoption of green farming, both for risky environmentally friendly practices are risky and non-risky ones. As expected, the incentive payment has a positive impact on adoption. The amount is sufficient to cover for the extra costs and the risk premium. However, when farmers face both types of risks, the incentive payment is significantly less efficient in encouraging the adoption of environmentally friendly practices.

Further research could focus on the role of risk management tools to encourage adoption of environmentally friendly practices. Can we kill two birds with one stone ? This suggests relying exclusively on risk management tools, rather than on a double system with risk management tools and agri-environmental measures. The experience of "Fondo Risemina Mais" in Veneto, Italy, is interesting in that respect (PANEurope, s. d.). This is a mutual fund where the farmers must comply with good agricultural practice and integrated pest management (including crop rotation), follow the recommendations of the arable crop protection bulletins from the Veneto Agriculture institute, and report any claims within the specified time periods. The farmer has access to the mutual fund (in the form of crop insurance) in case of pest damage to maize, as well as damage due to adverse weather conditions.

Beyond this particular research question, one can argue that such experimental evaluation tools allow to provide cheap and timely results, when behavioral factors are likely to modify farmers behaviors and traditional evaluation tools fail to account for such factors. Ideally, the experiment should be replicated with farmers in several EU countries. Nevertheless, decisions of agricultural students observed in a controlled experiment are already sufficient to challenge conclusions from traditional evaluation tools.

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Annexe: instructions