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Subjective barriers and determinants to crop insurance adoption

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Abstract

Crop insurance has a low rate of diffusion among French farmers. In this context, the objective of the article is to identify determinants and barriers to crop insurance from the point of view of the farmers. We designed an original survey using different methodologies (questions, experimental tests, self-ranking, Likert scales, etc.). We carried out cross-sectional and dynamic probit regressions on crop insurance adoption. We show that the characteristics of the farm (e.g., surface area, certification, diversification) and the farmers (e.g., marital and tenure status) as well as behavioral variables (e.g., time preferences) have an impact on the adoption of crop insurance. In addition, we show that the characteristics of the contract play an important role in the decision to subscribe or not since the farmers who are not insured consider the premium and deductible level to be the main barriers, whereas the farmers who adopt crop insurance report recent loss and expect poor weather conditions for the incoming season. We discuss the results with regard to the current crop insurance reform in France.

Keywords : Crop insurance, Farmers, Determinants, Barriers, Survey, France

JEL Classification : Q12: Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets; G22: Insurance, Insurance Companies, Actuarial Studies

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1 Introduction

Agriculture is currently facing multiple major challenges: the doubling of the global food production for 2050, the search for more environmental-friendly products, and the repercussions of climate change effects. The impact of climate change on European agriculture and its ability to increase its resilience is an increasing popular research topic (Meuwissen et al., 2019). Agriculture is vulnerable to climate change: higher temperatures impact yields and favor pest invasion, whereas changes in precipitation regimes increase the likelihood of short-term crop failures and long-term production decline (Nelson et al., 2009). In particular, climate change increases the frequency and severity of weather-related events. A recent study on the subject indicates that crop losses tripled between 1961 and 2015 in Europe due to the severity of drought and heat waves (Brás et al., 2021). However, Beillouin et al. (2020), showed that extreme events have varying impacts in different parts of Europe and losses in some areas could be compensated for by favorable conditions in other ones, which is in line with the results of Vaitkeviciute et al. (2019).

To deal with these-weather related events, farmers may take out crop insurance contracts. In fact, crop insurance was identified by the COP23 as a major tool to adapt to climate change (Drieux et al., 2019). These types of contracts are available in most European countries. It consists of an agreement between a farmer and an insurance company that stipulates that in return for an insurance premium, the insurer compensates the farmer for crop losses according to a set of pre-established parameters. Each contract specifies the insured crops and area, the events covered (drought, hail, flooding, etc.), the level of both the trigger threshold (i.e., the minimum amount of loss that triggers the indemnities) and the deductible (i.e., the share of loss that will not be indemnified). Each contract must also state the guaranteed yield. Several computation methods exist but they are usually based on the farmer's historical yield (e.g., the "olympic" average, which is the mean of the last 5 years after removing the highest and lowest yield values). The guaranteed price must also be fixed. For example, the mean of the historical price or a price fixed by a public authority could be used as the reference. After having determined all these parameters, the farmer can adopt different options to lower the deductible, for example, or increase the guaranteed yield.

Crop insurance schemes are usually supervised and promoted by public authorities through specificities and subsidies. The adoption rate of insurance is very heterogeneous between countries. In France, in addition to a 65% subsidy rate on the multi-peril offer, the crop insurance adoption rate remains low since only 30% of the French agricultural area is insured and large coverage disparities exist between crops. This excessively low diffusion rate threatens the sustainability of the offer. Other European countries are in a similar situation, like Italy, for example, whereas in other European countries, the adoption rate is quite high, like in Spain (see Koenig et al. (2022) for a comparison). Crop insurance is increasingly promoted by public authorities that aim to reach high levels of insurance coverage and reduce intervention through disaster payments. The scope of intervention of the disaster scheme is shrinking with the development of crop insurance in France. Since crop insurance is now the main climate risk management tool promoted by the government, with the ambition to make it a tool for adaptation to climate change, it appears essential to address issues in the current market and identify the main obstacles to crop insurance adoption and development. As Trieschmann et al. (2001) stated: "*as the size of the (insured) pool increases, the degree of risk faced by the pool as a whole decreases*". The future diffusion rate of crop insurance will be a key factor to the durability and sustainability of this instrument. This question is of utmost importance in France in the context of the reform of the crop insurance scheme (Descrozaille, 2021), as well as in other countries where the scheme is being reformed.

The aim of this article is to provide answers as to why crop insurance is not widely used in France. The potential variables that can impact the farmer's decisions to insure are diverse. The level of the insurance premium may be an important barrier. However, the quality of the services and coverage associated with this premium seem to be important as well. In addition, some behavioral variables may also contribute to the decision to insure or not. We propose to categorize them as follows: farm characteristics (area, crop, etc.), farmers' characteristics (age, income, etc.), crop insurance (premium, subsidy, etc.) and behavioral variables (risk aversion, risk perception, etc.). In addition, these variables are very heterogeneous; some are qualitative and others quantitative. We could not find any dataset that encompassed all of this information, so we designed an original online survey using different methods to collect information that allowed us to study the main factors affecting crop insurance adoption and, in particular, to identify the most important barriers to its adoption. This design has a certain level of genericity and may serve as a basis to address similar research questions in other countries.

In the following section, we propose to briefly describe the development of the French insurance scheme before presenting a brief review of the economic literature on crop insurance. We then lay out our survey and methodology. Finally, we present our results and conclude with a discussion.

2 Context and literature review

To fully comprehend the issue problematic linked to crop insurance in France, we first describe the development of the French crop insurance scheme. In the second part, we present the literature of which our research question is part.

2.1 The French crop insurance scheme

In France, the management of catastrophic risks is coordinated by the FNGRA (*Fonds National de Gestion des Risques en Agriculture*), a national fund dedicated to the management of the agricultural disaster scheme. This fund intervenes to indemnify farmers in the event case of non-insurable losses[1] caused by extreme weather events qualified as "agricultural disasters" by the public authorities. The scope of this fund tends to decrease as crop insurance develops but will remain necessary to cope with the extreme events that no insurance could cover. Farmers adopt different insurance contracts for their activity; some are mandatory (buildings, vehicles, personnel, etc.) and others are voluntary, among them, crop insurance, the one we focus on in this paper.

Historically, hail insurance was the only type of crop insurance available. Around the mid 1980s, storm and frost risks were integrated as options in hail insurance contracts. After several parliamentary reports (Babusiaux, 2000; Ménard, 2004), the government promoted the implementation of a new contract in 2005, known as MRC (*Assurance Multirisque Climatique*) insurance. This type of contract, which covers more than 15 different weather hazards (hail, drought, freezing, excessive rain or heat, gale force winds, etc.), is available for all farmers, regardless of the crop or location. Two types of MRC contracts are proposed: one provides coverage by "crop group" and the other one provides coverage at the "farm level". This distinction entails specifications on the characteristics of the contracts and how and when the compensation is triggered. In fact, 97% of the current MRC contracts adopted are of the "crop group" type (Descrozaille, 2021). The small subsidies existing for hail and frost policies were dropped in order to implement a 35% rate of subsidy for the MRC premium (funded by the European Agricultural Fund for Rural Development). To justify access to the subsidy, the design of the MRC policy is framed by a set of specifications updated by the Ministry of Agriculture each year: the crops and risks that can be covered, the deductible level, the trigger threshold, how both insured yield and price are computed, all the options available associated with a certain subsidy rate, and all the other obligations to which insurance companies and policyholders are subject.

The launch year of the MRC was quite a success. Given that the insurer proposed this contract as an extension of the former but remaining hail contracts, the adoption rate was considerable in 2005: 57,900 contracts subscribed, 3 billion euros of insured capital on 3.4 million hectares (22.37% of the French Utilized Agricultural Area (UAA)), 8.5 times more than in 2004 (Mortemousque, 2007). Despite this good start, the growth of the insured area in France has remained low ever since the initiative was launched. Having undergone a very slow development, the MRC scheme has experienced two major changes since its implementation in 2005. The first one, in 2010, thanks to a CAP (Common Agricultural Policy) reform that allowed fund transfers from the first pillar to the second one, the subsidy rate rose to 65% of the premium. The second one, in 2016, was a structural reform of the MRC that redesigned the architecture of the proposed contracts. From that time on, MRC insurance took the form of a three-layer coverage policy, as presented in Figure 1. First, the farmer adopts a "basic contract", subsidized at 65% and respecting basic characteristics (dark gray). The farmer can then ascribe to take a first level of supplementary guarantees, resulting in a premium surcharge that is eligible at a 45% subsidy rate (gray). Finally, the farmer can opt for a second level of supplementary guarantees for which there is no subsidy to support the premium surplus (light gray).

Despite the 2016 reforms that gave some impetus to the adoption rate, the share of insured land only increased by 10.4 percentage points over the 15 years of development of the MRC policy. The MRC adoption rate remains low and, more importantly, has large disparities in coverage between crops (see Appendix A). The diffusion rate of field crops is currently around 33% but with a low growth rate since 2005. For vegetables, the leap from 1.4% to 28% of the area covered is primarily explained by a reclassification of certain crops. The coverage of fruit crops is extremely low, which is particularly

[1]The overall combination of insurable risks and losses is set by the Ministerial Order of December 29, 2010.

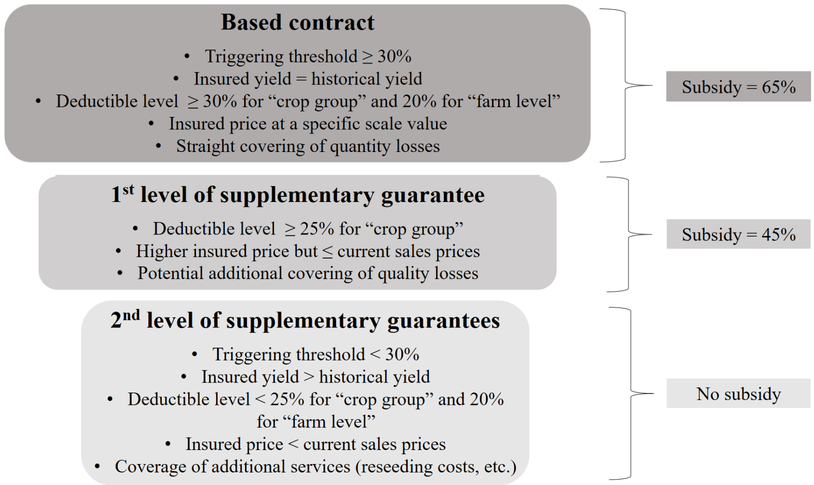

Figure 1: Characteristics of MRC contracts.

worrisome since they are the most weather-sensitive crops. Only viticulture is experiencing a steady growth in its diffusion rate, and has now reached now the same level as field crops.

In addition, the current insurance offer is not sustainable from the point of view of the insurers due to adverse selection issues. Indeed, insurers are compelled to pay out more claims on average than they collected in premiums at the beginning of the campaign. That measurement, referred to as the loss ratio, is the main indicator of the sustainability of the offer. By decreasing the loss ratio, adverse selection turns the policy into a loss for the insurer, leading to a permanent increase in premium to compensate for losses, gradually excluding the farmers from the market. In fact, to have a sustainable offer, this loss ratio has to be around the technical equilibrium of 75%.[2] Since the launch of the MRC offer in 2005, this equilibrium has only been achieved for the years 2008, 2014 and 2015. During the 2005-2018 period, the loss ratio was, on average 101%, reflecting a structural loss for the insurers (see Appendix A).

The low diffusion rate among French farmers and the structural deficit for the insurers are particularly problematic in a context of increasing risks due to climate change. Firstly, they reflect the lack of protection for a large part of French farmers, meaning that they may exclusively rely on disaster payments, whereas the scope of intervention of this public aid is gradually being reduced. Secondly, they imply a poor quality of pooling that threatens the sustainability of the offer.

On March 2, 2022, the new guideline law for a better distribution of crop insurance was enacted. Based on the report Descrozaille (2021), this law marks a new structural reform of the crop insurance scheme and its adequacy with the other risk management tools.[3] Since January 1, 2023, the subsidy rate has increased from 65% to 70% and the basic level of the deductible has decreased to 20% (applied from the next campaign, 2023-2024). This law also implements a "one-stop service desk" for farmers, which will pay out the compensation from both insurance contracts and disaster schemes.

2.2 Literature review

The insurance literature related to crop insurances and agriculture is quite old and heterogeneous. Its theory is based on the general literature on insurance (Rothschild and Stiglitz, 1978) and its problems of asymmetry of information (Pauly, 1978). It was adapted to the agricultural insurance framework in the 1980s by Ashan et al. (1982), Nelson and Loehman (1987) and Chambers (1989), among others. This theoretical framework highlighted the imperfections on this market and its non-optimal character. Public intervention is thus necessary in order to correct this asymmetry, support the development of the market through subsidies or even provide a public offer when there is a lack of private one. The empirical and analytical literature on this topic has been historically mainly focused on the American market.

[2] 100% would means that all the premiums are redistributed as compensations but the insurer requires a share of this premium to finance its management and reinsurance costs (Mahul, 1998).

[3] Agricultural orientation law no. 2022-298 of Marc 2, 2022, concerning the improved distribution agricultural harvest insurance with the intent to reform agricultural climate risk management tools. JORF n°0052 of March 3, 2022.

More particularly, a literature also developed on the determinants of crop insurance. Niewuwoudt and Bullock (1985) empirically analyzed the determinants of the crop insurance demand in the US using state data over the 1960-81 period from the Federal Crop Insurance Office. They found positive and significant effects on the adoption of crop specialization, expected rate of return and expected risk, farm size, disaster payments and part ownership. Crop insurance purchase was analyzed on the basis of this paper and tested at different states of market development in the US (Goodwin, 1993; Connor and Katchova, 2020), in different countries in Europe such as Spain (Garrido and Zilberman, 2008), the Netherlands (van Asseldonk et al., 2002) and Italy (Santeramo et al., 2016; Coletta et al., 2018), and even more recently, in developing countries[4] like Indonesia (Yanuarti et al., 2019), Pakistan (Fahad et al., 2018) and China (Wang et al., 2016; Lyu and Barré, 2017).

A more recent part of the economic literature pertaining to crop insurance focuses focusing on the effect of farmers' risk attitudes on the crop insurance purchase decision. Zhao et al. (2016, 2017) showed, with survey data, that farmers' risk-aversion positively and significantly affects the probability to purchase crop insurance. Meanwhile, they found an adverse selection effect since high-risk farmers are more likely to adopt crop insurance. However, they suggest that "substantial" crop insurance subsidies will even attract risk-neutral farmers to the market and also make it profitable for less risky-farmers. Yanuarti et al. (2019) also found that farmers have a relatively high-level of risk-aversion, which has a positive and significant effect on crop insurance participation. In the same way, Lyu and Barré (2017) showed that decision to purchase or not crop insurance is related to risk attitude, but they also find that insured amount affects this effect. According to their results, if the insured amount is high enough, risk aversion no longer affects the insurance purchase decision.
According to Sitkin and Pablo (1992) and Cho and Lee (2006), the two main components of behavior are risk attitude and risk perception (the personal assessment of probability to be subject to a specific hazard and its associated losses). Menapace et al. (2013) claim that a positive relationship between risk-aversion and risk-perception exists in that "*farmers who are more (less) risk averse tend to perceive greater (smaller) probabilities of farm losses occurring*". Looking specifically at risk perception, Vigani and Kathage (2019) found that a higher perception of risks has a positive and strongly significant impact on the adoption of insurance (and insurance combined with other risk management tools). In order to have a combined approach, van Winsen et al. (2016) used a survey to assess the effect of both risk attitude and risk perception on crop insurance adoption. Their results suggest that only risk attitude, and not risk perception affects farmers in their decision process. They also identify two types of farmers' profiles: farmers "willing to take risks" and "risk-averse" farmers. The first ones are more likely to apply *ex-ante* risk management tools such as insurance or diversification, whereas the others are more into an *ex-post* strategy in which they will face the impacts of losses by looking for off-farm income, delving into their savings or working harder to compensate.

Another behavioral variable that seems to affect crop insurance adoption is time preference. Indeed, the economic literature has identified the effect of time preference on insurance consumption, especially social insurance (Kifmann et al., 2010), whereas Coletta et al. (2018) also showed that time preferences have a significant impact on some risky decisions. They deduced that since crop insurance adoption also implies risk, time preferences should play a role, either positively or negatively.

The French case was studied by Enjolras and Sentis (2011) who used FADN (Farm Accountancy Data Network) data for the 2002-2006 period, corresponding to the period preceding MRC implementation. They found that the largest farms tend to insure more than smaller farms. Moreover, the farms considered as "high risk" are more prone to subscribe to a crop insurance contract. Finally, the authors underline a "fidelity to insurance", meaning that farmers who have already subscribed to a policy and who have previously received indemnities are more likely to subscribe again. Enjolras et al. (2012) took a common approach for France and Italy regarding the main determinants of crop insurance adoption and its elasticities of demand for the 2002 to 2007 period. They confirmed the existence of a "fidelity" or "inertia" effect regarding crop insurance participation for both countries. A key difference between both countries is the effect of diversification. While in Italy it has a negative effect on crop insurance, reflecting a substitute risk management tool, it has a positive effect in France, which means that diversification and insurance are considered as complementary in the risk management strategy of French farmers.

Recently, the literature concerning crop insurance in France was focused on its effect on farm management and especially on pesticide use. Möhring et al. (2020) found that crop insurance adoption is

[4] The application in developing countries is led by the emergence of a parametric insurance offer (Leblois and Quirion, 2013; Ye et al., 2020; Ghosh et al., 2021).

significantly associated with an increase in pesticide expenditures. Both tools are linked by an intensive and extensive margin effect, which implies both an increase in pesticide use per hectare and a cropland extension. Over the 2008 to 2012 period, Enjolras and Aubert (2020) found no specific impact of crop insurance on pesticide use for field crops and quality wine-growing. However, they found that crop insurance leads to a reallocation of land within the farm.

Crop insurance is an old topic in the agricultural economic literature. Nevertheless, the context of the country and the time of the study are important considerations with regard to the results. The different crop insurance schemes mentioned in the literature have and will experience structural reforms. Regarding the French situation, as we know, no recent academic study has focused on the actual state of the scheme. In addition, the empirical literature has focused on determinants to crop insurance, generally using European or American scale data. We consider that it could be relevant to look at barriers to crop insurance adoption. Barriers are not necessarily negative determinants. They may also be elements that block the functioning of the scheme or that are intrinsic characteristics of its design. To address this issue, we proposed to collect farmers' data through a survey.

We can categorize the variables studied by this literature into four groups: farm characteristics, farmers' characteristics, crop insurance and behavioral variables. Using this categorization, Appendix B proposes a summary table of the literature results. We also use this categorization and the literature results to formulate the research hypotheses presented in Table 1.

Table 1: Research hypotheses from the literature.

H1	**Farm characteristics significantly impact insurance adoption.**
H1a	Farm size (in area) is associated with a higher propensity to insure.
H1b	Using irrigation and other prevention tools reduces the willingness to adopt crop insurance.
H1c	Diversification (of crop or income) is negatively linked to crop insurance purchase.
H1d	Recent losses encourage farmers to adopt crop insurance.
H2	**Farmers' characteristics significantly impact crop insurance adoption.**
H2a	Farmers with lower income levels are less insured than the others.
H2b	Household size (i.e., having children in their care) reduces the likelihood of purchasing insurance.
H3	**Farmers past crop insurance choices significantly impact current insurance adoption.**
H3a	There is a "fidelity" effect: farmers who were previously insured tend to insure again.
H3b	Having already received compensation from an insurer will encourage the farmer to insure again.
H4	**Behavioral variables significantly impact crop insurance adoption.**
H4a	The higher the risk aversion is, the higher the probability to adopt crop insurance will be.
H4b	Risk perception and the feeling of vulnerability affect the likelihood of crop insurance adoption.
H4c	The more the farmer has a preference for the present, the less likely he or she will insure.

The objective is then to propose a relevant methodology to test these research hypotheses.

3 Methodology approach

In order to test these different hypotheses we needed information we could not find in any previously existing dataset. We therefore designed an online survey using different methods to question farmers about their crop insurance perception and adoption. In this section, we first describe our design and the sample. We then explain our econometric approach.

3.1 The design of our approach

The survey was distributed through the French Chambers of Agriculture network, a group of public organizations run by elected professionals from agricultural syndicates that represent French farmers and rural areas. We aimed to spread the survey among farmers in Metropolitan France, regardless of crop or location. The network we went through was the main channel to reach farmers without intentionally over-representing a category of farmers. We first contacted the national headquarters and then the 89 metropolitan departmental and interdepartmental offices with emails and phone calls. In order to respect anonymity rules, we asked them to diffuse the survey and the link necessary to complete the survey in their respective mailing lists or newsletters. Therefore, as we did not specifically know which offices diffused it or not, nor the number of people who received it, we were not able to determine how many farmers received this survey in their mailbox. However, we received responses from 25 different departments among which four are particularly represented (Aude, Jura, Nord, Vienne). The questionnaire was available between February 2021 to October 2021. We collected a total of 465 responses including 288 complete ones. The survey was completed by the farm manager. All the responses are anonymous with the two-digit department code as the most detailed information. Anonymization of our survey made it impossible to directly provide monetary incentives. To encourage farmers to complete the survey, we used an indirect incentive. We told farmers that a donation of €2 was made for each survey completed to the "Petits Princes" Association[5], as Ginder et al. (2009) did for their survey in northern Illinois.

The survey consisted of 57 questions, but none of the farmers answered the 57 questions since some of them were conditional. The survey was tested on a sample of researchers prior to its release to French farmers. Based on Cognitive Aspects of Survey Methodology studies and web-survey methods, we attempted to design our survey to avoid casual self-administered questionnaire issues (Tourangeau, 2003; Tourangeau et al., 2004). The order of the groups of questions and the questions within them was not random, but the order of the proposed answers to the questions was randomized when possible in order to reduce speeding (i.e., giving answers very quickly), straightlining (i.e., choosing the same response option for all items in a grid) and framing effects (i.e., bias for central positions) (Harrison et al., 2005; Zhang and Frederick, 2014). Moreover, we separated questions into several groups, each at different step of the survey, so that the respondents could not see the impact of their previous responses on the progress of the survey. Some responses could lead to other questions or, on the contrary, to not making them visible to the respondent. In order to prevent respondents from changing their minds because of the emergence of new questions, we hid these decisive questions as much as possible by putting them at a different step than the dependent questions. Finally, we did not mention the total number of possible questions and the progress bar of the survey in order not to influence or discourage the respondents.

We combined several methodologies to fully answer our research question. Using classical survey questions, we collected socio-demographic variables and characteristics of the farm. Among these questions, we had information related to the farmers' crop insurance. In addition, we used experimental tests to quantify risk preferences, self-ranking to measure the subjective degree of impatience, impulsiveness and exposure to weather hazards, 5-point Likert scales to identify the barriers to the adoption of crop insurance, and ranking to display the determinants of crop insurance purchase and the main barriers to its adoption. With the combination of these different methodologies, we hoped to capture as many of the potential explanatory variables as possible.

3.1.1 Classical survey questions

We asked the subjects to indicate if they had or would take out crop insurance for the 2020-2021 campaign (Insurance). We ask them if they were insured during the last growing season (InsT1), two years ago (InsT2), and the total number of years of subscription to a crop insurance contract (YearsIns). The last question asked them if they had already received compensation for crop loss from an insurer. Given that variable of interest in our study is the fact that the farmer is insured or not, we present all the descriptive statistics with this distinction: All, insured, non-insured. Table 2 presents the results to these questions.

We can observe that our sample is well-balanced since 49.31% of the farmers have an insurance contract (142/288). A total of 126 of them have a minimum of a MRC contract, 14 have a hail one, one a grassland contract and one has an revenue insurance. In addition, approximately half of the sample had an insurance contract during the last growing season and two years ago. On average, the farmers in our sample spent 7.7 years with a crop insurance contract, and 55.21% of the farmers had already received compensation for crop losses from an insurer. Some differences between the insured and the non-insured have to be highlighted. The insured in T were also mainly insured in $T-1$ and $T-2$, whereas few non-insured farmers in T were insured in previous years. In a similar way, many of the insured farmers had already received compensation from an insurer, whereas it was the case for only 26% of the non-insured farmers. Consequently, we expect that such variables impact insurance adoption.

Among the classical survey questions, we also have those related to farmers' and farms characteristics, whose answers are presented in Tables 3 and 4.

[5]Since 1987, the "Petits Princes" Association has been making dreams come true for seriously ill children and teenagers suffering from cancer, leukemia and certain genetic diseases.

Table 2: Crop insurance

Variables	Detail	All	Insured	Non-Insured
YearsIns	No. of years with a crop insurance contract	7.7 (9.9)	13.27 (9.8)	2.3 (6.6)
		in %	in %	in %
Insurance	Insured (proportion)	49.31	100	0
InsT1	Having a crop insurance contract in T-1	52.43	97.89	8.22
InsT2	Having a crop insurance contract in T-2	51.04	92.25	10.96
Compensation	Having received compensation for crop losses from an insurer	55.21	85.21	26.03
N	Number of observations	288	142	146

In our sample, farmers are on average of 49.65 years old and they are mainly men. Approximately 10% are located in the North of France, 29% in the West, 23% in the East and 36% in the South. The household is generally composed of two people or four or more people. We observed a large heterogeneity concerning income, with more than 70% of the sample between €1000 and €4000. For more than half of the farmers, their spouses working outside of the farm. Finally, 40% of them receive income from a non-agricultural activity.

The average area of the farms is on average 98.13 hectares.[6] Respondents have generally managed their farms for an average of 20.51 years. There is a variety of possible combinations among cultivated crops. However, certain profiles are more frequently represented. Among our respondents, 28.82% produce only wine, 27.43% produce only field crops producers, 17.36% produce both field crops and breed animals, 9.03% only breed. 29.17% of the farmers use irrigation, 28.47% are involved in a contractualization process or are integrated into a supply chain, 78.47% are part of a farm cooperative and 57.64% are members of an agricultural union. Most of the farmers are owners and tenants (63.54%), and for 71.88%, the farm was previously managed by a family member. A total of 36.46% of the farms are certified (organic farming, geographical indication, environmental certification, etc.). More than half of the farmers work with others on the farm; 83.33% of the farmers supply nitrogen to their crops; 48.61% of the farmers have already received a disaster payment; and 65.97% have suffered from a yield loss due to weather events in the last 2 years.

3.1.2 Experimental test for risk preferences

Risk aversion was measured by an Ordered Lottery Selection (OLS) methodology proposed by Reynaud and Couture (2012) and Brunette et al. (2017), which are adaptations of the Eckel and Grossman (2002, 2008) lottery tasks. We chose to implement this method because the measurement of risk preferences is based on only one lottery choice, which is clearly an advantage since this measurement procedure was part of a long questionnaire. In addition, this method was initially developed to address the risk preferences of rural farmers (Binswanger, 1980). All of the farmers face the nine gambles presented in the first three columns of Table 5 and we ask them to choose the gamble that they accept to play for. Each gamble is a fifty-fifty gamble with a 50% chance to obtain payoff 1 and a 50% chance to obtain payoff 2. The choice is purely hypothetical; there is no incentive[7]. The choice of a gamble makes it possible to infer an interval for the relative risk aversion coefficient (column 4), from "extremely risk-averse" (RA5) to "highly risk-prone" (RP3), and including through risk-neutral (RN) (column 5). The higher the number is, the higher the intensity of the individual's preference is. A coefficient equal to zero means risk neutrality, whereas a positive one indicates risk aversion and a negative one represents a risk-prone behavior.

The last three columns of Table 5 provide the distribution of the farmers' choices among our sample. A large majority of them selected Gamble 1, insured or not, corresponding to a high level of risk aversion.

[6]This is higher than the national mean of 63 ha and less than the national mean of the large farms: 111 ha. This group of large farms (in the economic sense) represents 73% of the French cultivated land, while medium-size and small farm groups represent 20% and 7% of it, respectively (INSEE).

[7]Some papers show the absence of difference in terms of decisions between lottery choices using hypothetical or real payoffs (Battalio et al., 1990; Wik et al., 2004).

Table 3: Farmers' characteristics

Variables	**Detail**	**All**	**Insured**	**Non-Insured**
Age	Age of the farmer	49.65 (10.3)	50.43 (10.9)	48.90 (9.5)
Gender	1 for men	0.816	0.838	0.794
		in %	in %	in %
Education	(1) = No Diploma	1.04	0.70	1.37
	(2) = General Certificate of Secondary Education	18.06	16.90	19.18
	(3) = High School Diploma	27.08	30.99	23.29
	(4) = 1 and 2 years University level	27.08	27.46	27.40
	(5) = 3 years University level	27.43	8.45	9.59
	(6) = 4 years University level	4.51	2.11	6.85
	(7) = 5 years University level	11.46	12.68	10.27
	(8) = 6 to 8 years University level	1.39	0.70	2.05
Location	(1) = North of France	10.76	11.27	10.27
	(2) = West of France	29.17	23.94	34.25
	(3) = East of France	23.26	16.90	29.45
	(4) = South of France	36.81	47.89	26.03
HouseholdSize	(1) = 1 person	12.15	8.45	15.75
	(2) = 2 persons	31.94	36.62	27.40
	(3) = 3 persons	19.44	19.72	19.18
	(4) = 4 or more persons	36.46	35.21	37.67
Income	(1) = <€1000	7.99	3.52	12.33
	(2) = [1000:2000[	31.94	30.99	32.88
	(3) = [2000:3000[	23.61	25.35	21.92
	(4) = [3000:4000[	17.36	18.31	16.44
	(5) = [4000:5000]	6.60	9.15	4.11
	(6) = >€5000	5.56	3.52	7.53
	(7) = Prefers not to answer	6.94	9.15	4.79
SpouseOcupation	(1) = Spouse works outside of farm	53.82	57.75	50
	(2) = Spouse doesn't work outside of farm	29.86	28.87	30.82
	(3) = Single	16.32	13.38	19.18
NonAgriIncome	Non-agricultural activity income	41.32	43.66	39.04

We also computed the average risk aversion coefficient of the whole sample, which is 1.32 (s.d. 1.0). Among the insured farmers, the average coefficient is 1.37 (s.d. 0.9) and among the non-insured, it is 1.26 (s.d. 1.1).

Table 4: Farm characteristics

Variables	Detail	All	Insured	Non-Insured
Surface area	Cultivated hectares	98.13 (100.7)	103.57 (99.2)	92.84 (102.2)
FarmExp	Years as farm manager	20.51 (12.7)	21.69 (13.0)	19.36 (12.3)
		in %	in %	in %
TypeAgri	Agricultural activity (1) = Field Crops	27.43	29.58	25.34
	(2) = Wine	28.82	38.03	19.86
	(3) = Field Crops and Breeding	17.36	17.61	17.12
	(4) = Breeding	9.03	1.41	16.44
	(5) = Diversification (all others)	17.36	13.38	21.23
Irrigation	Irrigation user	29.17	32.39	26.03
Contract	In a contractualization process	28.47	33.8	23.29
Coop	Member of a cooperative	78.47	89.44	67.8
Syndicate	Member of a trade union	57.64	62.68	52.74
Tenure	(1) = Owner	23.26	28.87	17.81
	(2) = Tenant	13.19	9.86	16.44
	(3) = Owner and tenant	63.54	61.27	65.75
FamilyFarm	Farm previously managed by a family member	71.88	79.58	64.38
Label	Certification	36.46	42.25	30.82
WorkForce	Working with others on the farm	51.04	57.04	45.21
Nitrogen	Nitrogen supply to crops	83.33	88.73	78.08
Disaster	Already received a disaster payment	48.61	63.38	34.25
RecentLoss	Yield losses due to weather events in the last 2 years	65.97	75.35	56.85

Table 5: Measurement of risk preferences

50/50 gamble	Payoff 1	Payoff 2	Coef. of RRA ranges	Coef. of RRA code	All in %	Insured in %	Non-insured in %
Gamble 1	40	40	$r > 1.37$	RA5	60.42	60.56	60.27
Gamble 2	32	51	$0.68 < r < 1.37$	RA4	12.15	16.90	7.53
Gamble 3	24	64	$0.44 < r < 0.68$	RA3	6.25	3.52	8.90
Gamble 4	16	78	$0.4 < r < 0.44$	RA2	5.21	5.63	4.79
Gamble 5	12	86	$0.15 < r < 0.4$	RA1	5.90	5.63	4.79
Gamble 6	8	91.5	$-0.13 < r < 0.15$	RN	4.86	3.52	6.16
Gamble 7	6	92.9	$-0.47 < r < -0.13$	RP1	0	0	0
Gamble 8	4	93.4	$-0.93 < r < -0.47$	RP2	0.69	0.70	0.68
Gamble 9	1	93.5	$r < -0.93$	RP3	4.51	3.52	5.48

3.1.3 Self-ranking for subjective patience, impulsiveness and exposure to weather hazards

Patience is used here as a proxy for time preference measurements. An ultra-short and self-measure of this parameter has been tested and validated by Vischer et al. (2013).
Impulsiveness is, along with patience, the control of behavioral factors that could affect a decision. Impulsiveness is not used as a proxy for time preferences but it can capture the effect of triggering elements that can explain a specific behavior (purchase or decision) (Vischer et al., 2013). Consequently, we used two self-assessment scales, one to estimate the degree of patience and the other for impulsiveness. The scales are from 0 to 10 where 0 corresponds to “very impatient” or “not at all impulsive” and 10 to “very patient” or “very impulsive”. The respondents have to select their own self-perceived degree of patience and impulsiveness with a cursor going from 0 to 10, one by one. For the self-perception of farm exposure to weather hazards, we used a self-ranking scale, going from 0 for “very little exposed” to 5 for “very strongly” exposed.

On average, farmers are patient (5.98/10) not so very impulsive (4.28/10) and they think that their farms are quite exposed to weather-related events (3.31/5). Few differences appear between the insured and the non-insured.

Table 6: Impatience, Impulsiveness and Exposure

Variables	**Detail**	**All**	**Insured**	**Non-Insured**
Patience	0=very impatient to 10=very patient	5.98 (2.4)	5.91 (2.3)	6 (2.5)
Impulsiv	0=not impulsive to 10=very impulsive	4.28 (2.5)	4.4 (2.6)	4.1 (2.4)
FarmExposure	0=very little to 5=very strongly	3.31 (0.98)	3.47 (0.9)	3.15 (1.03)

3.1.4 5-point Likert scale to identify the potential barriers to the adoption of crop insurance

For the barriers, we asked the subjects to express their level of agreement or disagreement for each of the 13 proposed reasons for not using the MRC contract, presented in Table 7, with five levels: Strongly disagree (1), Somewhat disagree (2), Indifferent (3), Somewhat agree (4), Strongly agree (5). The table presented the average score of each of the potential barriers on a scale from 1 to 5.

Table 7: Potential barriers to the adoption of crop insurance

Variables	**Detail**	**All**	**Insured**	**Non-Insured**
BarrierPRICE	Too high price	4.16 (1.0)	3.9 (1.2)	4.37 (0.8)
BarrierDED	Too high deductible	4.2 (0.9)	4.19 (1)	4.21 (0.9)
BarrierTRIG	Too high threshold for triggering compensation	4.09 (1)	4.04 (1.1)	4.13 (0.9)
BarrierSHIFT	The time lag between the payment of the insurance and the payment of the grant generates cash flow problems	3.42 (1.1)	3.29 (1.2)	3.54 (1)
BarrierADMI	Too many administrative documents	3.3 (1.2)	2.89 (1.2)	3.7 (0.9)
BarrierINCO	Incompatibility of the proposed contracts with the growing calendar	2.76 (1.2)	2.27 (1)	3.24 (1.1)
BarrierPROB	Too low probability of receiving compensation	3.78 (1.2)	3.22 (1.3)	4.3 (0.9)
BarrierYIELD	The method used to calculate the guaranteed return (based on historical data) makes the coverage too low	4.0 (1.1)	3.96 (1.1)	4.05 (0.99)
BarrierPREV	Having adopted sufficient measures to prevent or fight against weather hazards	2.18 (1.1)	1.84 (0.9)	2.51 (1.2)
BarrierTRUST	I do not trust insurers	2.91 (1.2)	2.46 (1.1)	3.35 (1.2)
BarrierDIVE	I have diversified my activities enough to withstand a loss caused by weather hazards	2.59 (1.3)	2.03 (1.1)	3.14 (1.3)
BarrierCOMP	The time limit for receiving compensation for crop loss is too long	3.01 (1.1)	2.65 (1.2)	3.36 (0.9)
BarrierEARLY	I have to make my decision to subscribe too early in my campaign	2.95 (1.2)	2.62 (1.2)	3.27 (1.1)

We can observe that some barriers are clearly identified among the sample. In particular, those related to the characteristics of the insurance contract clearly appeared. For example, the fact that the level of the deductible is too high (*BarrierDED*), the price level is too high (*BarrierPRICE*) and the threshold for triggering compensation is too high (*BarrierTRIG*) were among the most frequently represented. Some differences between the insured and the non-insured respondents also appear concerning variables like *BarrierPROB* and *BarrierINCO* where more than a 1 point difference exists between the two sub-samples.

3.1.5 Ranking to identify potential determinants of crop insurance purchase and barriers to its adoption

A ranking methodology has been previously used done in a self-administered survey on crop insurance issues by Ginder et al. (2009). Consequently, in order to identify the determinants of insurance adoption, we asked the insured respondents (N=142) to rank the first three proposals (TOP3) that most highly encourage them to insure among the following ones: forecasted/anticipated bad weather, external advice (cooperative members, neighbors, insurers, etc.), the level of subsidy, having previously suffered losses due to weather-related hazards, the flexibility of the contract and the options available, the obligations (due to contracting or the integrated sector, owner's request, etc.), a change of rotation or crop.

In addition, we asked the non-insured respondents (N=146) to rank the TOP3 proposals that "would" most encourage them to insure: lower insurance price, higher level of subsidy, grant applied directly at the time of payment, reduced administrative procedures, lower deductible and threshold for triggering compensation, higher insured yield, higher guaranteed price for compensation, cover for loss of quality, cover for losses due to pests, diseases and weeds.

We made the different proposals according to the results of our literature review and the hypotheses and assumptions we made.

Concerning the potential barriers, we asked the farmers to select the TOP3 that they considered to be the most important barriers among the 13 proposals presented in Section 3.1.4.

3.2 Econometric strategy

We proposed a random utility model (RUM, McFadden and Reid (1975)) in order to explain the choice to adopt or not to adopt a crop insurance contract.

Let v_i, be the level of utility of the farmer i for the insurance adoption y_i. Since y_i represents the adoption of a crop insurance contract, it can take on two modalities: $y_i = 1$ for a crop insurance subscription or $y_i = 0$ for no insurance coverage. Thus, two levels of utility can be defined, v_0 and v_1, the utility level of non adoption and adoption of crop insurance, respectively. The farmer i will adopt a crop insurance contract if $v_1 > v_0$ with:

$$v_{i0} = v_0(W_i - ELoss_i(RL_i, EXP_i, X_i, K_i), \epsilon_{0i}) \tag{1}$$

$$v_{i1} = v_1(W_i, p_i, X_i, \epsilon_{1i}) \tag{2}$$

where W_i is the total income of the i^{th} farmer and X_i is a set of explanatory variables representing farm and farmers' characteristics. $ELoss_i(RL_i, EXP_i, X_i, K_i) = \gamma_1 RL_i + \gamma_2 EXP_i + \gamma_3 X_i - \gamma_4 K_i$ is a function representing the expected loss in the event of weather hazard, where RL_i is the recent loss incurred, EXP_i is a subjective perception measure of exposure to weather hazards, and K_i is the prevention tool in place. p_i is the insurance premium. Finally, ϵ_i is an error term for unobserved variations.

The i^{th} farmer will insure if the difference in utility is higher than the disutility of the perceived cost of insurance ψ_i:

$$v_1 - v_0 > \psi_i(G_i, X_i, \epsilon_{2i}) \tag{3}$$

where G_i a set of barriers related to the contract characteristics and market design of crop insurance.

On that basis, we can define the latent variable y^*:

$$y_i^* \equiv v_1 - v_0 - \psi_i \tag{4}$$

With v_0, v_1 and ψ being linear functions, we can develop the indirect utility functions:

$$v_0 = \alpha_{01} + \alpha_{02} W_i - \alpha_{02}\gamma_1 RL_i - \alpha_{02}\gamma_2 EXP_i - \alpha_{02}\gamma_3 X_i + \alpha_{02}\gamma_4 K_i + \epsilon_{0i} \tag{5}$$

$$v_1 = \alpha_{11} + \alpha_{12} W_i + \alpha_{13} X_i - \alpha_{14} p_i + \epsilon_{1i} \tag{6}$$

$$\psi_i = \alpha_{21} + \alpha_{22} G_i + \alpha_{23} X_i + \epsilon_{2i} \tag{7}$$

From (5), (6) and (7), we can define:

$$y_i^* = \alpha_1 + \alpha_2 W_i + \alpha_3 X_i - \alpha_{14} p_i + \alpha_{02}\gamma_1 RL_i + \alpha_{02}\gamma_2 EXP_i - \alpha_{02}\gamma_4 K_i - \alpha_{22} G_i + \epsilon_{012i} \tag{8}$$

with $\alpha_1 = \alpha_{11} - \alpha_{01} - \alpha_{21}$; $\alpha_2 = \alpha_{12} - \alpha_{02}$; $\alpha_3 = \alpha_{13} - \alpha_{02}\gamma_3 - \alpha_{23}$ and $\epsilon_{012i} = \epsilon_{1i} - \epsilon_{0i} - \epsilon_{2i}$

Thus, the decision to insure (*y=1*) or not (*y=0*) can be represented as follows:

$$y_i = \begin{cases} 1 & \text{if } y_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{9}$$

We split our econometric approach into a two-step analysis regarding the binary variable of crop insurance adoption (insured or not for the ongoing campaign) as our variable of interest.

In the first step, we processed the cross-sectional data from our survey through a probit model (Eq. 10).

$$Pr(y = 1|G_i, K_i, X_i, W_i, RL_i, EXP_i) = \Phi[\delta G_i + \gamma K_i + \beta_1 X_i + \beta_2 W_i + \beta_3 RL_i + \beta_4 EXP_i] \quad (10)$$

where y is the binary variable on crop insurance adoption, G and K are vectors of potential barriers to insurance adoption and prevention tools implemented, respectively (Table 7), X is a vector of farm and farmers' characteristics (Tables 3, 4, 5 and 6), W represents the income (Table 3), RL is the occurrence of recent losses (Table 4) and EXP is the subjective measure of risk exposure (Table 6).

In the second step, we adopted a dynamic approach of the adoption of crop insurance (Eq. 11). In the survey, the respondents were asked whether or not they were also insured in T-1 and T-2 (two separate questions). With this information, we constructed an alternative panel database of our responses, assuming a constant set of parameters (area, participation in a cooperative or trade union, family situation, measures of behavioral variables, etc.) over the three years studied. Using this database of 864 observations (288 individuals over 3 years), we performed a dynamic probit model. We estimated a dynamic random effects probit model with unobserved heterogeneity using the **xtpdyn** on Stata developed and presented by Grotti and Cutuli (2018). The regression equation is presented in Grotti and Cutuli (2018) as follows:

$$\begin{aligned} &Pr(y_{it} = 1|y_{i,t-1}, ..., y_{i0}, G_i, K_i, X_i, W_i, RL_i, EXP_i, Z_{it}, c_i) = \\ &\Phi[py_{t-1} + \delta G_i + \gamma K_i + \beta_1 X_i + \beta_2 W_i + \beta_3 RL_i + \beta_4 EXP_i + \sigma Z_{it} + c_i] \end{aligned} \quad (11)$$

with

$$c_i = \alpha_0 + \alpha_1 y_{i0} + \alpha_2 \bar{Z}_i + \alpha_3 Z_{i0} + a_i \quad (12)$$

where y_{it} is once again the binary variable on crop insurance adoption for individual i at period t, y_{it-1} captures the state dependence, Z is a vector of time-varying explanatory variables considered to be strictly exogenous, conditional on the unit-specific unobserved effect c_i. y_{i0} and Z_{i0} are the initial value of the dependent variable (crop insurance) and of the time-varying explanatory variables, respectively. $\overline{Z}_i = \frac{1}{T}\sum_{i=0}^{T} Z_{it}$ is the time-average of the explanatory variables, a_i is a specific time-constant error term, normally distributed with mean 0 and variance σ_a^2 (Grotti and Cutuli, 2018).

In order to provide instrumental data for the dynamic approach, we collected departmental climate data for the years 2017, 2018 and 2019. Thus, we completed the database with information on the departmental minimum and maximum temperature recorded during the year (*Min. Temperature* and *Max. Temperature*), the cumulative annual rainfall (*Total Precipitation*) and sunshine (*Total Sunshine*) and the maximum gust speed recorded over the year (*Max. Wind gust*). Since the decision to insure or not for the forthcoming campaign has to be made at the end of the calendar year, we matched 2019 climate data for the decision to insure or not for 2020, 2018 data for the decision for 2019, and 2017 data for 2018.

4 Results

We propose to analyze our results in two steps. In the first step, we present the results of the econometric strategy dealing with the determinants and barriers to the adoption of a crop insurance contract. In the second step, we focus on adopters (of insurance contracts), on the one hand, and non-adopters, on the other, and the variables that support them in their choice. The first step will use econometrics to test our assumptions and the second will verify our results and classify the relative importance of our different variables.

4.1 Determinants and barriers to insurance adoption

Since our approach is based on the analysis of barriers to insurance adoption, we first regressed our variable of interest with the different barriers presented in Table 7. We then added all the control variables[8] and parameters at our disposal. Table 8 presents the results of two cross-sectional probit regressions (Eq. 10) and Table 9 presents the results of the complete[9] dynamic probit regression (Eq. 11). We begin with the interpretation of Table 8.

[8]Both *Education* and *Income* variables are treated as continuous variables in the models. The "Prefer not to answer" respondents for *Income* were included in category (3) since it is the median.

[9]Table 13 of Appendix C presents six regressions that progressively lead to the full model presented here.

Table 8: Cross-sectional probit regressions.

	Crop Insurance adoption	
	(1)	(2)
BarrierPRICE	-0.201^{*}	-0.217
BarrierDED	0.263^{**}	0.587^{**}
BarrierTRIG	0.322^{**}	0.282
BarrierSHIFT	0.060	0.289
BarrierADMI	-0.177^{**}	-0.112
BarrierINCO	-0.293^{***}	-0.350^{*}
BarrierPROB	-0.563^{***}	-0.813^{***}
BarrierYIELD	0.176	-0.040
BarrierPREV	-0.035	-0.300
BarrierTRUST	-0.111	-0.438^{**}
BarrierDIVE	-0.265^{***}	-0.152
BarrierCOMP	-0.129	-0.297^{*}
BarrierEARLY	0.082	0.174
TypeAgri		
1.Field Crops (FC)		0
2.Wine		0.716
3.FC and Breeding		0.699
4.Breeding		-1.070
5.Diversified-other		0.214
Localisation		
1.North		0
2.West		-0.645
3.East		-1.341^{**}
4.South		0.538
Surface area		0.004
Irrigation		-0.323
Contract		-0.739^{*}
WorkForce		0.712^{*}
Coop		1.751^{***}
Syndicate		-0.485
FarmExp		-0.017
FamilyFarm		0.623
Label		0.877^{**}
Nitrogen		0.096
Disaster		0.437
Compensation		2.052^{***}
RecentLoss		1.483^{***}
Age		-0.001
Gender		0.819^{*}
Education		-0.001
Marital		
0. Single		0
1. Married or Civil-union		0.945
2. Divorced or Widowed		0.577
3. NSPP		-0.551
HouseholdSize		-0.338
SpouseOccupation		
1.Single		0
2.Yes		-0.584
3.No		-1.043
Income		-0.048
NonAgriIncome		-0.119
Tenure		
1.Landowner		0
2.Tenant		-1.679^{**}
3.Tenant-Owner		-0.795^{*}
FarmExposure		0.252
CoeffRA		-0.011
Patience		0.135^{*}
Impulsiv		0.037
Constant	2.313^{***}	-1.432
R^2	0.3581	0.6894
Observations	288	288

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9: Dynamic probit regression.

	Crop Insurance adoption
	(3)
L.Insurance	3.21^{***}
BarrierPRICE	-0.286
BarrierDED	-0.202
BarrierTRIG	0.430^{*}
BarrierSHIFT	0.319
BarrierADMI	-0.041
BarrierINCO	-0.155
BarrierPROB	-1.06^{***}
BarrierYIELD	0.208
BarrierPREV	-0.157
BarrierTRUST	-0.441^{**}
BarrierDIVE	-0.114
BarrierCOMP	-0.053
BarrierEARLY	0.186
TypeAgri	
1.Field Crops	0
2.Wine	-1.069
3.FC and Breeding	0.248
4.Breeding	-0.952
5.Diversified-other	0.089
Localisation	
1.North	0
2.West	1.705
3.East	-1.514
4.South	-1.497
Surface area	0.009^{***}
Irrigation	-0.412
Contract	-0.210
WorkForce	0.703
Coop	0.734
Syndicate	-0.506
FarmExp	1.627
FamilyFarm	0.692
Label	1.109^{*}
Nitrogen	0.059
Disaster	0.222
Compensation	0.828^{*}
RecentLoss	
Age	
Gender	0.384
Education	-0.097
Marital	
0. Single	0
1. Married or Civil-union	1.398^{*}
2. Divorced or Widowed	-0.785
3. NSPP	-1.748
HouseholdSize	-0.129
SpouseOccupation	
0.Single	0
1.Yes	-1.398
2.No	-2.330^{**}
Income	0.044
NonAgriIncome	0.259
Tenure	0.221
1.Landowner	0
2.Tenants	-2.105^{**}
3.Tenant-Owner	-1.364^{**}
FarmExposure	0.221
CoeffRA	-0.020
Patience	0.116
Impulsiv	0.074
Min. Temperature	0.177
Max. Temperature	0.956^{*}
Total Precipitation	0.008
Total Sunshine	-0.004
Max. Wind Gust	-0.017
Constant	72.85
Observations	576
Number of groups	288

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the first regression in Table 8, we test the effects of the barriers to insurance adoption. We observe that the barriers alone lead to a R^2 of 0.35, which already explains one-third of the insurance adoption. Among the 13 potential barriers we propose to rate from 1 to 5, we find a significant effect on the decision to insure for seven of them. Two of them have a positive and significant impact: the excessively high level of the deductible ($BarrierDED$) and of the threshold for triggering compensation ($BarrierTRIG$). Our results suggest that the more the farmers find the deductible level too high (as well as the triggering threshold), the more likely they are to insure. These results, particularly counter-intuitive, imply that insured farmers well understand the implication of the contract characteristics and emphasize their dissatisfaction regarding these two characteristics (usually at the same level) through this ranking. Meanwhile, we could say that non-insured farmers are not particularly aware of these characteristics or that their choice to insure or not is made before they even look at the different terms of the contracts. The five other barrier proposals have a negative and significant impact on insurance adoption. Thus, the excessively high price ($BarrierPRICE$), too many administrative documents ($BarrierADMI$), the incompatibility of the proposed contracts with the growth calendar ($BarrierINCO$), the low probability of receiving compensation ($BarrierPROB$) and the sufficient diversification of the activities ($BarrierDIVE$) act as a disincentive to insurance adoption. The cost of insurance is naturally the biggest barrier for the farmers. As we will see later, 171 farmers ranked this proposal as one of their TOP3 deterrents. The purpose is to see beyond this first step and to look at the specifications of the contract proposed at this cost. Moreover, the administrative management of the crop insurance contract is a significant barrier for adoption. If insurance is too costly in terms of time and required information, the farmers are discouraged to insure. The fact that the decision to insure could be too early for the farmer's growing season seems to be a determinant. Considering themselves diversified enough is a major element explaining the non-subscription to the insurance scheme, which has notably also been highlighted by Falco et al. (2014).

Introducing the other variables improves the adjustment with a R^2 of 0.69. The effect of the barriers is slightly modified since the variables $BarrierPRICE$, $BarrierTRIG$, $BarrierADMI$ and $BarrierDIVE$ are no longer significant, whereas $BarrierTRUST$ and $BarrierCOMP$ become significant. The "Compensation" barrier indicates that non-insured farmers believe that the time taken for compensation in the event of a claim is too long, which seems to go along with the notion of trust. Indeed, we find a negative effect of our barrier "Trust", which means that not trusting the insurer negatively affects the likelihood of insurance adoption. This result is intuitive. In addition, as shown in Fig. 2, the non-insured farmers rank this notion of trust much more often in their TOP3 barriers.

Concerning the other variables tested, we found no specific effect of the different typologies of agricultural activities that we tested. Our sample is highly composed of wine growers and field crop producers, both being the most highly insured compared to the other types of farmers. Location has a significant impact only for farmers in eastern France who are less likely to insure than those located in the north. Farmers involved in a contractualization process (either upstream or downstream of the sector) are less likely to insure. Contractualization can already be perceived as an element of risk management. In contrast, being part of an agricultural cooperative has a significant and positive effect, whereas belonging to a syndicate has no impact.

Concerning the farm's characteristics, we observe that the surface area has no impact, nor do the use of irrigation or nitrogen. However, having a certification ($Label$), being part of a farm cooperative and working with others on the farm ($WorkForce$) have a significant and positive effect on insurance adoption. In the same way, having suffered from yield losses due to weather events in the last 2 years ($RecentLoss$) and having already received compensation for crop losses from an insurer ($Compensation$) significantly encourage insurance adoption.

Finally, we show that some farmers' characteristics also impact insurance adoption. In particular, the tenure seems to be important. Indeed, being a tenant or tenant-owner (as compared to a landowner) significantly discourages the farmer to insure compared to the full ownership situation. The income level is treated here as a continuous variable (and not in the categorical way presented in Table 3) but does not appear to be significant. The last significant variable is the degree of patience. We find that the more patient farmers think they are, the more likely that they will subscribe to crop insurance, which is consistent with the economic literature concerning time preference, discount rate and insurance demand (Hill et al., 2013). We found no significant effect of risk aversion and impulsiveness measures on crop insurance adoption.

Now, if we look at Table 9, we observe that some of the results are similar to those presented in Table 8. This is the case for the variables $Tenure$, $Compensation$ and $Label$. However, some differences appear as well. Because of the way the question was asked, the variable $RecentLoss$ could not be preserved in the construction of the panel dataset. The variable $Surface\ area$ is now positively significant, meaning that the larger the farm is, the greater the incentive will be to adopt an insurance contract, which is in line with Enjolras and Sentis (2011). The farmer's marital situation appears to be significant as well: being married or in a civil union has a positive and significant impact compared to being single. Moreover, the fact that the spouse does not work outside of the farm reduces the chances of crop insurance adoption. The significant barriers are also different: $BarrierTRIG$ has a positive effect, whereas $BarrierPROB$ and $BarrierTRUST$ have a negative one. Concerning the instrumental variables, only the annual maximal temperature has a significant and positive effect on farmers' insurance adoption. The main point of running this dynamic analysis was to assess the impact of the previous (T-1 and T-2) adoption of insurance on the current adoption decision (T). We found that the variable *L.Insurance* is positive and highly significant, reflecting an inertia for previously insured farmers that confirms the results of Enjolras and Sentis (2011) and Enjolras et al. (2012).

4.2 Adopters vs. non-adopters: the variables of influence

4.2.1 Identification of the main barriers

In the previous section, we used the results of the 13 5-point Likert scales linked to the proposed barriers to the adoption of crop insurance. After this step, respondents had to classify their TOP3 among these proposals (Table 7) in the survey. Looking at the ranking, we can observe that additional information is provided their relative perception of the crop insurance scheme and its characteristics. The following figure (Fig. 2) represents the occurrences of answers as TOP1 (dark gray), TOP2 (gray) and TOP3 (light gray) among the proposals of main barriers to crop insurance adoption for both insured *(i)* (N=142) and non-insured *(n)* (N=146) respondents.

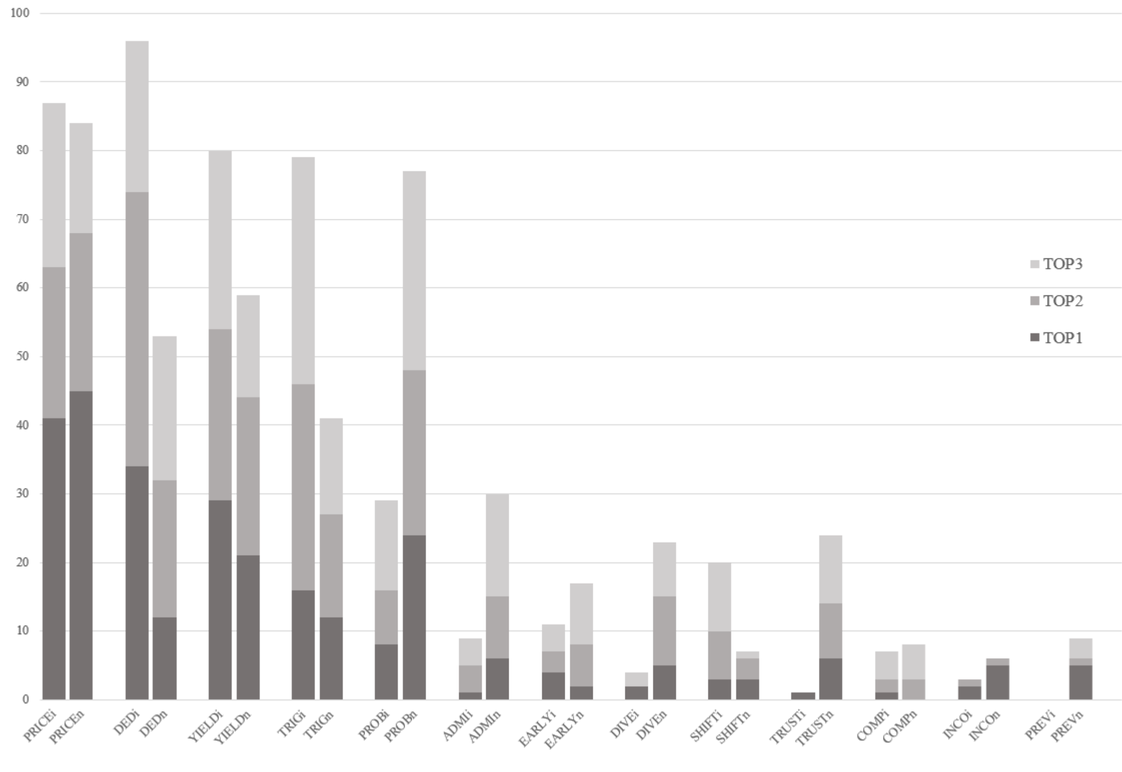

Figure 2: Main barriers to crop insurance adoption for insured (indexed i) and non-insured (indexed n) respondents.

It appears that insured and non-insured respondents do not rank the barrier proposals in the same order. For both populations, the price of the insurance (i.e., the premium) is an important barrier, as expected, but the proposal "the probability of receiving a compensation seems too low to me" is ranked second for the non-insured population, whereas it is ranked fifth for the insured population. This difference could reflect an adverse selection effect, or at least a subjective one, in which the insured farmers feel at risk. The characteristics of the contract, such as the deductible level, triggering threshold or insured yield, appear to be important barriers, especially for the insured population. The deductible level proposal, even though it ranks first less often, has a higher recurrence in the global TOP3 classification of the insured population.

As expected, we found more recurrence of the proposals linked to the diversification and the prevention tools for the non-insured population, which confirms the negative and significant effect of *BarrierDIVE* (Table 8).

The administrative burden linked to the subscription and followed by the application for the subsidy is much more often classified as a top barrier for the non-insured than for the insured population (which confirms the sign and significance of *BarrierADMI* in Table 8).

4.2.2 The determinants of adoption (or entry)

In the following section, we use the third group of questions linked to the determinants of crop insurance adoption. Figures 3 and 4 represent the classification made by crop insurance adopters regarding elements that convinced them to insure and non-adopters regarding potential changes that could convince them to adopt crop insurance, respectively. Both figures represent the occurrences of answers as TOP1 (dark gray), TOP2 (gray) and TOP3 (light gray) among the proposals.

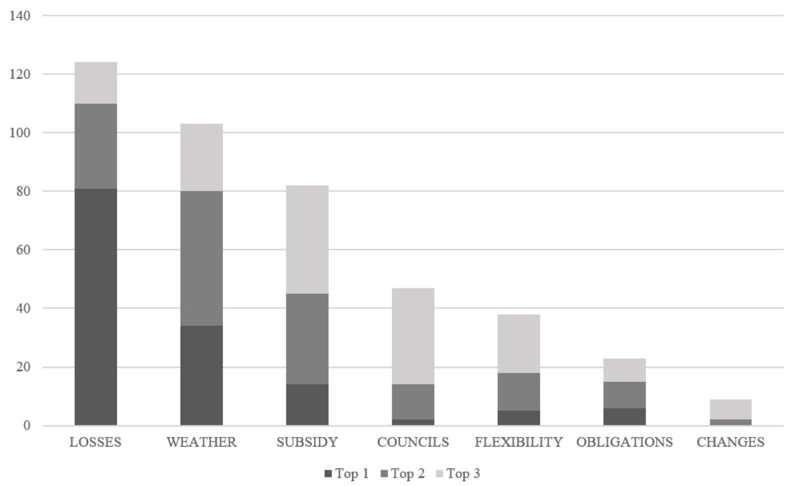

Figure 3: Factors encouraging crop insurance adoption.

For the crop insurance adopters (Fig. 3), the occurrence of previous crop *Losses* due to weather hazards is by far the most important factor among the proposals. Out of the 142 adopters, 81 ranked it as their first motivation. This confirms the positive and significant effect of the variable *RecentLoss* obtained in Table 8. In total, 124 of them placed this proposal in their TOP3. *Weather* forecasting is the second most important element, followed, in third place, by *Subsidy.* This highlights the importance of the meteorological projections given in October for the respective germination and growth period of crops. Among the other proposals, *Obligations* is the fourth most frequent TOP1 ranking proposal. Crop insurance adoption could be mandatory in different contracts in which the farmer is a signatory. More data and deeper analysis regarding the quality of coverage of this kind of profile would be particularly relevant. Moreover, it appears that crop insurance is not seen as an obvious tool to support a change in practices since the proposal *Changes* is by far the least often chosen.

For the non-adopters (Fig. 4), as expected, the reduction of the insurance *Premium* is by far the main factor that could convince farmers to join the crop insurance market. A total of 104 out of the 146 non-adopters placed this proposal in their TOP3, 58 of whom ranked it as the first factor. It appears important to link this proposal with the proposals at the level of *Direct Subsidy* and its payment modalities. An increase in the subsidy or a decrease in the premium should be seen as substitutes, but our results suggest that it does not appear to be so for farmers. This is probably partially due to the modality of payment of the subsidy. In addition to impacting cash flow, particularly for smaller farms, the time lag between the payment of the premium and reception of the subsidy has an impact on the farmer's perception of the cost of insurance. Indeed, due to this time lag, it is likely that the farmers, in their mind, disconnect the payment of the premium and the reception of the subsidy, especially since they may receive different subsidies for their farms for different reasons (decoupled aid, coupled animal aid, compensatory allowance for natural handicaps, etc.). Once again, the deductible level[10] appears to

[10]This proposal also took into the triggering threshold into consideration since it was presented as "A lower

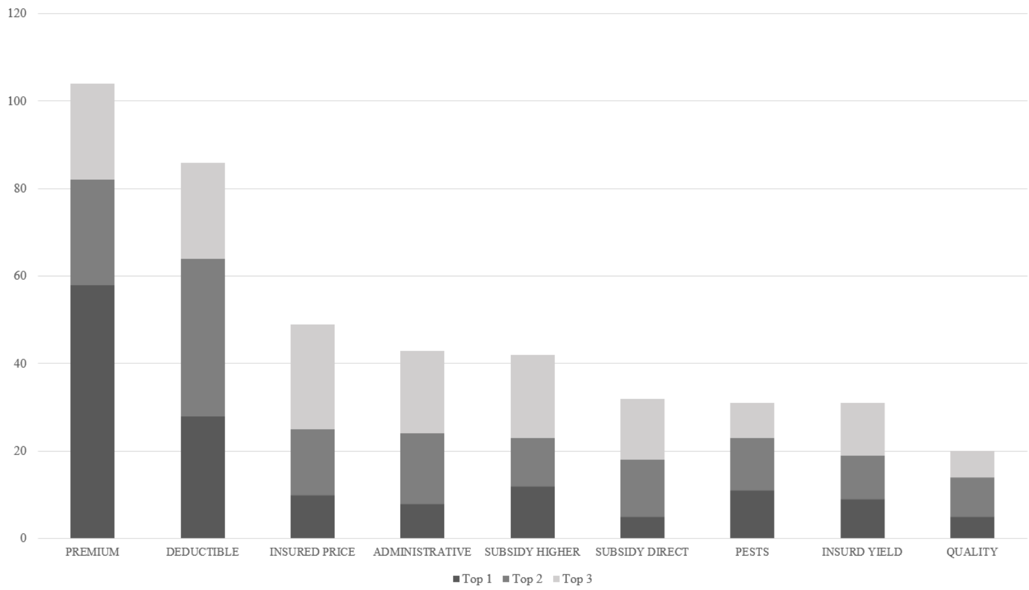

Figure 4: Potential entry factors in the crop insurance market.

be a major feature of interest. The other proposals have relatively the same rate of occurrence.

Regarding the contract characteristics, reducing the level of deductible and triggering threshold (*Deductible*)[11] is the main factor (after *Premium*) that could tempt non-adopters to adopt insurance. Even if these parameters are more frequently declared as an issue for the insured population (Table 8 and Table 9), reducing the level of both parameters should tempt hesitant farmers to insure. The *Insured price*, controlled by an official chart, appears to be more of an issue than the *Insured yield* modality (based on an "olympic" average). *Pests* and *Quality* coverage are among the last proposals. More data and deeper analysis would be necessary to analyze these two proposals. We assume that these parameters are more important for fruit and vegetable growers who are not numerous enough in our sample and who are the least covered by crop insurance contracts, even if they produce the most weather-sensitive products.

5 Discussion

5.1 Summary of the results

We summarize the results of the hypothesis testing in Table 10.

To sum up our results and review our hypotheses, we found that the occurrence of recent loss (**H1d**) and having already received compensation from an insurer (**H3b**) increase the likelihood to adopt crop insurance. Farmers already insured tend to insure again, which can be interpreted as an "inertia" or "fidelity" effect toward crop insurance (**H3a**). In terms of farm and farmers' characteristics, we found no significant effect that crop insurance is less often adopted by farmers with lower income levels (**H2a**), but we found a significant and positive effect of the farm size (in hectares) in (2) (**H1a**). We found no effect of household size (**H2b**) on the likelihood of crop insurance purchase. Regarding behavioral variables, we did not find a significant effect, either for risk aversion (**H4a**) or for risk perception (**H4b**). Time preferences, that we assessed with the patience measurement, influence crop insurance adoption (**H4c**) since the least patient farmers are significantly less likely to insure; however the impulsiveness measure has no significant effect. Concerning the other risk management tools and strategies, we show that diversification (**H1c**) has a significant and negative effect, whereas irrigation has no impact (**H1b**). Finally, the perception farmers have of the contract characteristics affect significantly affects their decision, and intrinsic brakes exist in the design of the scheme, such as the administrative burden associated with it and the incompatibility of the proposed contracts with the growing calendar.

deductible and threshold for triggering compensation".

[11] Usually at the same level. The triggering threshold could be higher than the deductible but not the opposite.

Table 10: Hypothesis validation.

H1		**Farm characteristics**
✓	H1a	Farm size ↗
X	H1b	Irrigation and diversification ↘
✓	H1c	Diversification ↘
✓	H1d	Recent losses ↗
H2		**Farmers' and household characteristics**
X	H2a	Lower income level ↘
X	H2b	Household size ↘
H3		**Past crop insurance experience**
✓	H3a	"Fidelity" or "Inertia" effect ↗
✓	H3b	Having already received compensation ↗
H4		**Behavioral variables**
X	H4a	Risk aversion ↗
X	H4b	Risk perception ↗
✓	H4c	Preference for the present ↘

Three stages of analysis seem to follow each other in the process of deciding whether or not to buy crop insurance for a farmer.
First: *Is the likelihood of being damaged and compensated for high enough?* This first step is highlighted by the importance of the expected weather in the factors that influence insurance adoption (Fig. 3), the perceived probability of compensation in Fig. 2, and the significance of the variable *BarrierPROB* in our models (Tables 8 and 9). Since crop insurance is not mandatory like other traditional insurance contracts, farmers may perceive the crop insurance subscription as an "investment" or a "bet" from which they want a return (effect also highlighted for flood insurance by Kunreuther and Pauly (2005)). This questioning is also influenced by the trust in the insurer: that if losses occur, the insurers do not try to avoid compensation. Trust is more an issue for the non-insured than for the insured (Fig. 2), which seems to be counterbalanced by experience with crop insurance and, in particularl, having been compensated in the past (Tables 8 and 9).

Then: *If I receive a compensation, how much will it be? Will this level of compensation satisfy me?* Here, we take a closer look at the contract characteristics and how the combination of these parameters provides information on the level of compensation for a given loss.[12] The deductible level appears as a major element of consideration for farmers as can be seen by its significance in the regression (Table 8), in the classification of the barriers (Fig. 2) and in the potential entry factors (Fig. 4). This parameter, closely linked to the triggering threshold, reveals the part of the damage not compensated for and, therefore, the level of loss above which compensation will be paid (since the deductible and triggering thresholds are usually at the same level, we suspect a confusion of their roles for some farmers that we did not investigate).

Finally: *Taking into consideration the probability I perceive of being compensated and the "quality" of this compensation, is the premium I have to pay worth it?* According to the interest the farmers assess of adopting crop insurance, they will judge the level of premium required for coverage. The premium level appears as the main barrier, as expected (Figs. 2 and 4). The price of insured is also significant through the variable $BarrierPRICE$ (Table 8, model (1)). In order to sustain the offer and reduce the impact of this brake, public authorities have implemented large subsidies. However, this principle of interchange-ability between a reduction of the premium and an increase of the subsidy as a reduction of the premium level appears as the main factor to convince farmers to take out insurance, but an increase in the subsidy level appears only in fifth position among these factors (Fig. 4). We assume that the shift between the payment of the premium and the payout of the subsidy is one of the main explanatory factors. Even if it does not appear to be significant in our model, we found, after analysis of the brakes according to income groups, that it is an issue especially for farms with the least cash flow capacity and could be an explanation for the lowest adoption rate of fruit farmers where the high value

[12] A compensation is defined by the loss rate its triggers (i.e., triggering threshold), the share of the losses actually compensated for (i.e., deductible) and the insured amount (i.e., historical yield) associated with the insured price.

and vulnerability of the crops induce a high level of premium per hectare. Moreover, crop insurance expenses are consistent with a global risk management allowance. Thus, farmers may decide to invest in other instruments such as prevention tools or bet on other risk management strategies like agricultural and non-agricultural diversification (prevention and diversification level perception appears to be more important for the non-insured (Fig. 2), and the variable *BarrierDIVE* negatively and significantly affects the likelihood of crop insurance adoption (Table 8, model (1)). Since all of the efforts and investments made for prevention are not valued by a reduction in the level of the premium, even though it decreases the risk-exposure of the farmers, these kinds of instruments are substitutes for crop insurance from the farmer's point of view.

This whole line of reasoning is influenced by the farmer's profile. As previously mentioned, time preference, measured with the *Patience* variable, positively and significantly influences the likelihood of crop insurance adoption (Table 8), assigning a higher value to future compensation than farmer with a strong preference for the present would assign. Risk perception, impulsiveness and risk attitude do not have a significant effect on the likelihood to purchase crop insurance.

5.2 Public policy implications

Three degrees of risks are usually considered. They correspond to the OECD approach in terms of risk management and resilience in agriculture: a normal and usual risk, frequent and with low impact left to the farmer's charge; a marketable risk, less frequent and with higher impact that could be transferred to an insurer if it meets the insurability criteria; and a catastrophic risk, infrequently provoking high damage to production and impacting a large number of farmers for which a public intervention is required. The French government is currently considering this three-layer approach[13] and adapting its risk management policy in agriculture by proposing and subsidizing different tools. In relation to the normal risk (the first layer), French authorities encourage the implementation of prevention tools, which include, self-protection and self-insurance mechanisms (Ehrlich and Becker, 1972). Self-protection tools aimed at reducing the probability of occurrence of the damage, like hail nets, anti-frost devices and irrigation systems, can be the subject of public investment aid. Similarly, the French government promotes self-insurance tools aimed at reducing the damage in the event of risk occurrence. For example, the government encourages precautionary savings through tax deductions with the *"Déduction pour épargne de précaution (DEP)"*, which makes it possible to place a share of the annual profits on a specific account with the aim of using it to smooth out the farmer's income in the following years.

For the policy-maker, the challenge is to create or maintain the synergy and complementarity of these tools with crop insurance. The national strategy follows this three-layer approach, where each layer is associated with different instruments. In the name of coherence and efficiency, prevention tools, crop insurance and disaster aids have to be perceived by farmers as being complementary, which is currently not the case. Prevention efforts should be taken into consideration when determining the premium level, and the scope of the agricultural disaster scheme should be clarified. The new reform[14] develops these two points. The next set of specifications drawn up by public authorities will establish measures and practices that are intended to decrease the premium level if implemented by the insured person. The complementarity between crop insurance and disaster scheme is then defined by a threshold of compensation. According to the size of the losses, farmers will be compensated by either their insurers or the FNGRA but with a single point of contact ("one-step service desk"). Moreover, the share of public assistance related to disaster events will slowly decrease for non-insured farmers.

We have seen in our analysis that the deductible level is a major parameter regarding crop insurance contracts, especially for farmers who are already insured. Farmers perceive it as a main barrier and it seems to make adoption less attractive since it was still ranked as the second major barrier by the non-insured respondents. The incoming reform (applied as of January 1, 2023) introduces a reduction from 30% to 20% of the deductible level for the basic MRC contract. In their evaluation report, Boucher et al. (2019) state that the deductible reduction option is quasi-systemic for MRC subscribers but implies a considerable increase in the premium since going from a 25% to a 20% level implies, according to their estimation, a 40% surplus of the premium (a 40% subsidy rate is eligible on this surplus). The standardization of the 20% rate may attract more farmers and will be included in the main subsidy rate.

[13]Draft law n°4758, reforming the tools for managing climate risks in agriculture, December 1, 2021.

[14]Agricultural orientation law no. 2022-298 of March, 2, 2022, concerning the improved distribution of agricultural harvest insurance with the intent to reform agricultural climate risk management tools. JORF n°0052 of March 3, 2022.

The reform also implements a measure originally intended in the OMNIBUS regulation[15] by raising the main subsidy rate from 65% to 70%. This increase in the subsidy is intended to encourage adoption. However, even if the amount of the subsidy is considerable, we argue that the way the subsidy is distributed is also particularly important and should be improved. In order to really perceive the subsidy as a reduction in the premium level, this subsidy should be directly applied when paying the insurance premium, as it is the case in Spain, for example. Public authorities may consider the creation of an entity responsible for handling this time lag, like AgroSeguro in Spain.
The stated goal of public authorities is to expand the insured pool as much as possible in order to increase its pooling quality and lessen the standard market failures of insurance markets (moral hazard and adverse selection). The French Federation of Insurance (Fédération Française de l'Assurance, FFA) estimates that 70% of the French agricultural area should be insured to achieve technical and financial equilibrium in the market (Descrozaille, 2021). This reform should help to move in this direction, but there is no evidence of major changes in the less insured crops that would encourage them to enter the market. Since their implementation, MRC contracts have never convinced the fruit growers, and additional and specific studies in this area seem necessary. It appears that a significant proportion of farmers have a fairly fixed idea about their insurance needs and that this idea is not challenged every year. In our models, the characteristics of the contracts are particularly significant for the insured farmers, whereas the non-insured farmers are more likely to highlight the obstacles related to the compatibility of their situation and the lack of need and trust for insurance coverage. More widespread information on available offers and their greater adaptability could convince new farmers to enter the market.
Our results imply an inertia effect in crop insurance adoption that has previously been highlighted by Enjolras et al. (2012) and Santeramo (2019). Santeramo (2019) particularly underlines the role of information and experience in the crop insurance adoption process in Italy and suggests that it may be relevant to add an additional subsidy to the main one for a first subscription in order to convince farmers to enter the market. Regarding how significant and important the fact of being insured during the previous year is in our results, we can only take up and support this proposal. The problem arises, however, as to the compatibility of such a measure with WTO rules.
Further research could focus on the expansion of the scope of risks covered by the current crop insurance contract toward pests, diseases and insect risks. Current single and multi-peril contracts available in France only cover weather-related events, whereas in the US, multi-peril contracts cover weather hazards and pest risks. Since these risks are also major concerns for farmers, the extension of insurance coverage could attract new policyholders and improve the quality of mutualization. The proposal *PESTS* does not appear in the top proposals of potential entry factors (Fig. 4), but we assume that it would be ranked higher if our sample was composed of a higher proportion of fruit and vegetable growers.

6 Conclusion

This paper is part of a debate in France (as well as in other European countries) on the reform of the crop insurance scheme. In particular, since the current scheme encompasses only 30% of the agricultural surface area, the question of the determinants and barriers to the adoption of an insurance contract is relevant. To address this question, we propose an original survey approach that combine different methodologies in order to capture as many as possible of the potential explanations. In this context, we confirm some existing effects (recent loss, inertia, etc.) and we display new ones, especially concerning the behavioral variables (patience) and the identification of relevant barriers (price, deductible, trigger, etc.). We discuss the policy implications of these results.

The collection of the data was complicated and quite long. We succeeded in collecting 288 full answers, but we expected more in the beginning. A deeper analysis could have been made if more responses had been collected. Because of our sample size, we were not able to analyze the crop insurance adopters in greater depth. In particular, we had variables regarding the type of contract and the various options the farmers subscribed to, but we could not use this information in this article. It would have been interesting to look at the differences in contracts adopted regarding risk perception and preferences, as well as at the differences in choices made between farmers who voluntarily subscribe and those who subscribe to respect contractual clauses. Moreover, a main issue regarding the current French crop insurance scheme is the large inequalities of coverage between crops. Unfortunately, we lacked responses from fruit and vegetable growers who are the least insured and among the most exposed to weather

[15] The OMNIBUS regulation was adopted in 2017 by the European Parliament within the framework of the new CAP guidelines. This new regulation should have come into operation in January 2018 but has been delayed.

hazards and climate change. Further research in these directions should be privileged.

A relevant extension to the current research would be to consider other behavioral variables. First, measuring ambiguity preferences may be an interesting issue. Indeed, the literature has already shown the role of ambiguity aversion in an insurance context, both experimentally and theoretically (Kunreuther et al., 1995; Alary et al., 2013). In addition, farmers' ambiguity aversion has already been quantified, including for French farmers (Bougherara et al., 2017; Tevenart and Brunette, 2021). However, the link between farmers' ambiguity preferences and crop insurance adoption has never been established. Consequently, measuring ambiguity aversion, in addition to risk aversion, may allow a finer representation of farmers' behavior. To do this, the experimental measurement of ambiguity preferences based on the MPL approach has been proposed by Chakravarty and Roy (2009) and may be helpful. Second, we can envisage including loss aversion, considered in Prospect Theory (PT) (Kahneman and Tversky, 1979). Indeed, some articles show that French farmers behave, to some extant, in accordance with PT (Reynaud and Couture, 2012; Bocquého et al., 2014; Bougherara et al., 2017). Expected Utility theory does not distinguish between gains and losses, whereas in PT, outcomes are categorized as either gains or losses as regards a reference point, and individuals can behave differently in each domain. In addition, PT allows us to consider the probability weighting that refers to an individual's tendency to distort objective probabilities. A classical way in experimental economics to estimate the different parameters of the PT is the MPL methodology proposed by Tanaka et al. (2010). Such observations auger particularly interesting avenues for future research.

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A Appendix A. Evolution of the MRC policy since 2005

Table 11: Evolution of the MRC policy since 2005.

Diffusion rate	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**
Fields Crops	25%	25.8%	27.1%	28.9%	26.0%	27.6%	30.3%	30.8%	31.7%	30.9%	26.5%	26.4%	30.1%	31.0%	32.1%	33.3%
Wine	0.6%	10.2%	11.5%	12.9%	13.7%	15.8%	17.1%	18.8%	19.2%	23.6%	23.3%	25.0%	26.2%	31.5%	32.4%	34.0%
Fruits	0.8%	1.7%	1.9%	2.1%	2.2%	2.4%	2.7%	2.7%	2.4%	2.5%	2.2%	2.6%	2.7%	2.8%	2.8%	3.1%
Vegetables	1.4%	3.5%	7.6%	12.0%	10.7%	12.2%	13.9%	15.5%	15.6%	16.6%	15.0%	14.4%	24.6%	25.2%	27.7%	28.0%
Total without Grassland	**22.4%**	*	*	*	*	**26.5%**	**29.0%**	**29.6%**	**30.3%**	**29.9%**	**26.3%**	**25.8%**	**29.4%**	**30.5%**	**31.6%**	**32.8%**
Total with Grassland												14.8%	16.8%	17.2%	17.9%	18.2%
Number of contracts	57,883	66,936	69,273	70,771	68,029	72,201	77,138	80,454	75,833	75,828	68,378	65,483	69,399	70,126	70,157	71,602
Loss Ratio	81%	97%	130%	57%	87%	80%	104%	90%	127%	62%	69%	231%	108%	91%	*	*

* for missing official information

Sources: Authors with public data from the French Ministry of Agriculture and from the 2022 Budget Bill: Agriculture, food, forestry and rural affairs.

B Summary of the results of the literature

Table 12: Significant effect of variables studied in the literature on crop insurance adoption.

Variables	**Positive effect**	**Negative effect**	**Lack of significance**
Farms characteristics			
Farm size (area)	Knight and Coble (1997); Enjolras and Sentis (2008)	Niewuwoudt and Bullock (1985)	
Farm size (economic)	Enjolras and Sentis (2008); Enjolras et al. (2012) *(for Italy)*	Black and Dorfman (2000)	Enjolras et al. (2012) *(for France)*
Land ownership	Finger and Lehmann (2012); Fahad et al. (2018)	Sherrick et al. (2004) Niewuwoudt and Bullock (1985)	Vigani and Kathage (2019)
Diversification	Enjolras et al. (2012) *(for France)*	Knight and Coble (1997) Santeramo et al. (2016)	
Irrigation	Enjolras and Sentis (2011); Santeramo et al. (2016)	Foudi and Erdlenbruch (2012)	Coble et al. (1996); Serra et al. (2003)
Disaster payments	Just and Calvin (1994); Smith and Baquet (1996) Deryugina and Kirwan (2018)	Niewuwoudt and Bullock (1985) van Asseldonk et al. (2002) Meuwissen et al. (2018)	
Farmers' characteristics			
Age	van Asseldonk et al. (2002)	Black and Dorfman (2000) Enjolras and Sentis (2011)	Vigani and Kathage (2019) Finger and Lehmann (2012)
Education	Wang et al. (2016); Fahad et al. (2018)	Black and Dorfman (2000)	Gardner and Kramer (1986) Enjolras et al. (2012)
Having children		Sulewski and Kłoczko-Gajewska (2014)	
Farm experience	Black and Dorfman (2000); Fahad et al. (2018)		
Crop failure experience	Enjolras and Sentis (2011) Kurdys-Kujawska and Sompolska-Rzechula (2018) Yanuarti et al. (2019)		
Crop insurance			
Premium subsidies	Garrido and Zilberman (2008); Ginder et al. (2009)		
Crop insurance experience	Enjolras and Sentis (2011); Wang et al. (2016) Santeramo (2019)		
Behavioral variables			
Risk aversion	Zhao et al. (2016, 2017) Yanuarti et al. (2019) Lyu and Barré (2017)	van Winsen et al. (2016)	
Risk perception	Vigani and Kathage (2019)		
Time preferences	Coletta et al. (2018)	Coletta et al. (2018)	

Source: Authors.

C Dynamic models

Table 13: Regression results.

	Crop Insurance adoption					
	(1)	(2)	(3)	(4)	(5)	(6)
L.Insurance	3.06***	3.06***	3.43***	3.17***	3.21***	3.21***
Min. Temperature	0.61	/	0.012	0.108	−0.009	0.177
Max. Temperature	0.61	0.855	0.550*	0.731*	0.742*	0.956*
Total Precipitation	0.002	0.007	0.004	0.007	0.004	0.008
Total Sunshine	−0.004	−0.006	−0.003	−0.004	−0.004	−0.004
Max. Wind Gust	−0.012	−0.026	−0.008	−0.021	−0.004	−0.017
BarrierPRICE	0.006			−0.076	0.206	−0.286
BarrierDED	−0.24			0.006	−0.142	−0.202
BarrierTRIG	0.428			0.332*	0.364*	0.430*
BarrierSHIFT	−0.022			0.027	0.085	0.319
BarrierADMI	−0.218			−0.129	−0.092	−0.041
BarrierINCO	−0.076			−0.008	−0.146	−0.155
BarrierPROB	−0.636			−0.553***	−0.612***	−1.06 ***
BarrierYIELD	0.111			0.107	−0.042	0.208
BarrierPREV	−0.041			−0.103	0.000	−0.157
BarrierTRUST	−0.201			−0.251*	−0.225*	−0.441**
BarrierDIVE	−0.182			−0.239**	−0.055	−0.114
BarrierCOMP	0.06			0.009	0.047	−0.053
BarrierEARLY	0.171			0.074	0.232	0.186
TypeAgri						
1.Field Crops		0		0		0
2.Wine		−0.151		0.027		−1.069
3.FC and Breeding		−0.455		0.228		0.248
4.Breeding		−2.02		−1.215		−0.952
5.Diversified-other		−0.268		0.076		0.089
Localisation						
1.North		0		0		0
2.West		3.983		0.745		1.705
3.East		1.50		−0.425		−1.514
4.South		0.022		−0.496		−1.497
Surface area		0.005		0.005**		0.009***
Irrigation		−0.304		−0.120		−0.412
Contract		−0.233		−0.193		−0.210
WorkForce		0.641		0.343		0.703
Coop		1.30		1.05**		0.734
Syndicate		−0.172		−0.244		−0.506
FarmExp		1.552		1.320		1.627
FamilyFarm		0.20		0.128		0.692
Label		0.195		0.180		1.109*
Nitrogen		−0.449		−0.384		0.059
Disaster		0.54		0.301		0.222
Compensation			0.710***		0.787***	0.828*
Age			0.870		1.26	
Gender			−0.092		−0.086	0.384
Education			0.027		−0.001	−0.097
Marital						
0.Single			0		0	0
1.Married or Civil-union			0.758*		0.589	1.398*
2.Divorced or Widowed			0.123		−0.216	−0.785
3.NSPP			0.017		−1.296	−1.748
HouseholdSize			−0.067		−0.147	−0.129
SpouseOccupation						
1.Single			0		0	0
2.Yes			−0.423		−0.167	−1.398
3.No			−0.455		−0.433	−2.330**
Income			0.125		0.131	0.044
NonAgriIncome			0.102		0.007	0.259
Statut						0.221
1.Landowner			0		0	0
2.Tenants			−0.276		−1.096*	−2.105**
3.Tenant-Owner			−0.209		−0.614	−1.364**
FarmExposure			0.190		0.224	0.221
CoeffRA			0.045		0.026	−0.020
Patience			0.050		0.057	0.116
Impulsiv			0.116**		0.113**	0.074
Constant	−14.865	−11.70	−6.06	18.81	−11.88	72.85
Number of groups	288	288	288	288	288	288
Observations	576	576	576	576	576	576

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$