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 test, self-ranking, likert scale, etc.). We realized cross-sectional and dynamic probit regressions on crop insurance adoption. We show that the characteristics of the farm (e.g., diversification) and the farmers (e.g., income level) 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 have an important role in the decision to subscribe or not since the farmers who are not insured rank the premium and deductible level as 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 as regards 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 multiples major challenges: double the global food production for 2050, product with more environmental friendly practices, and cope with climate change effects. Climate change impacts on European agriculture and its ability to increase its resilience is an increasing 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-run crop failures and the long-run production decline (Nelson et al., 2009). In particular, climate change increases the frequency and severity of weather related events. A recent work on the subject indicates that the severity of drought and heatwaves crop losses tripled between 1961 and 2015 in Europe (Brás et al., 2021). However, Beillouin et al. (2020), showed that extremes events have varying impacts in different parts of Europe and losses in some areas could be compensate 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, the farmers may adopt crop insurance contract. Indeed, crop insurance was identified by the COP23 as a major tool to adapt to climate change (Drieux et al., 2019). Such contract is available in most of the European countries. It is an agreement between a farmer and an insurance company, which stipulates that in return of an insurance premium the insurer compensates the farmer for crop losses respecting a set of 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 indemnify). Each contract must also states the guaranteed yield. Several computation methods exist but they are usually based on the farmer's historical yield (like the "olympic" average which is the mean of the last 5 years removing the highest and lowest value of yield). The guaranteed price must also be fixed, for example: a mean of the historical price could be the reference or a price fixed by a public authority. After having determined all this 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, besides a 65% subsidy rate on the multiperil offer, the crop insurance adoption rate remains low as only 30% of the agricultural French area is insured and important coverage disparities exist between crops. This too low diffusion rate threaten the sustainability of the offer. Other European countries are in a similar situation like for example Italy, whereas in others the adoption rate is quite high like for instance Spain (see Koenig et al. (2022) for a comparison). Crop insurance is more and more promoted by public authorities who aim to reach high level of insurance coverage and reduce the intervention through disaster payments. The scope of intervention of the disaster scheme shrinks as crop insurance develops in France. As crop insurance is now the main climate risk management tool promoted by the government and 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 the 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), but also 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 farmers' decisions to insure are various. 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 too. In addition, some behavioral variables may also contribute to the decision to insure or not. We propose to categorize them as follows: farms 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 data set gathering all these information, so that we design an original online survey using different methods to collect information allowing to study the main factors affecting crop insurance adoption and especially identify the most important barriers to its adoption. This design has a certain level of genericity and may serve as basis to address similar research questions in other countries.

We propose in the next section to briefly describe the development of the French insurance scheme before presenting a quick review of the economic literature on crop insurance. Then, we detail our survey and methodology. Finally, we present our results and conclude with a discussion.

2 Context and literature review

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

2.1 The French crop insurance scheme

In France, the management of the catastrophic risk 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 case of non-insurable losses[1] caused by extreme weather events qualified as "agricultural disasters" by 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 require to adopt for their activity different insurance contracts, some are mandatory (buildings, vehicles, personnel, etc.) and others are voluntary, among them, the one we focus on in this paper, the crop insurance.

Historically, hail insurance was the only type of crop insurance available. Around mid 80's, the storm and frost risks were integrated as options of hail insurance contracts. After several parliamentary reports (Babusiaux, 2000; Ménard, 2004), the government promoted the implementation in 2005 of a new contract named MRC insurance for *Assurance Multirisque Climatique*. This kind of contract, that covers more than 15 different weather hazards (hail, drought, frozen, excess of rain or heat, gale force winds, etc.), is available for all the farmers whatever the crop or location. Two types of MRC contract are proposed, one cover by "crop group" and the other one 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 "crop group" type (Descrozaille, 2021). The slight subsidies existing for hail and frost policies were dropped to implement a 35% rate of subsidy for the MRC premium (funded by the European Agricultural Fund for Rural Development). To justify the 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 to a certain subsidy rate, and all the other obligations to which insurance companies and policyholders are subject.

The launch year of the MRC has been quite a success. As the insurer proposed this contract as an extension of the old but remaining hail contracts, the adoption rate was important in 2005: 57,900 contracts subscribed, 3 billions euros of insured capital on 3.4 millions hectares (22.37% of the French Utilise Agricultural Area (UAA)), 8.5 times more than 2004 (Mortemousque, 2007). Despite this good start, the growth of the insured area in France has remained low since. Experimenting a very slow development, the MRC scheme has undergone two major changes since its implementation in 2005. The first one, in 2010, thanks to a CAP (Common Agricultural Policy) reform allowing funds transfers from the first pillar to the second one, the subsidy rate raised 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 there, the MRC insurance is a three layers covering policy as presented in Figure 1. First, the farmer adopts a "basic contract", subsidized at a 65% and respecting basic characteristics (dark grey). Then, the farmer can take a first level of supplementary guarantee, resulting in a premium surcharge which is eligible to a 45% subsidy rate (grey). Finally, the farmer can opt for a second level of supplementary guarantee for which there is no subsidy to support the premium surplus (light grey).

Despite the 2016 reforms that gives some impetus to the adoption rate, in 15 years of development of the MRC policy, the share of insured land only increased by 10.4 percentage points. The MRC adoption remains low and more importantly, with large disparities in coverage between crops (see Appendix A). Diffusion rate in fields crops is actually around 33% but with a low growth since 2005. For the vegetables, the leap from 1.4% to 28% of the area covered is mostly explained by a reclassification of certain crops. The coverage of fruits crops is extremely low which is particularly worrying as they are the most weather-sensitive crops. Only viticulture is experiencing a steady growth in its diffusion rate, reaching 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 issue. Indeed, insurers are compelled to pay out more claims on average than they

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

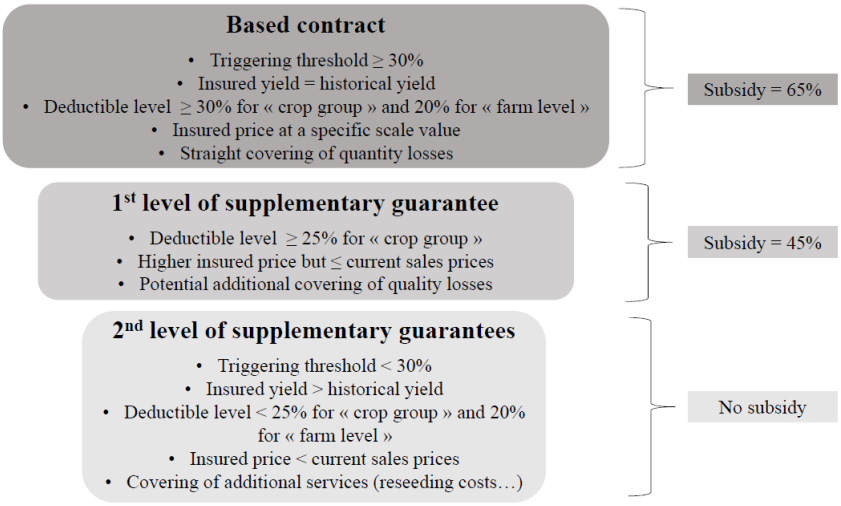

Figure 1: Characteristics of MRC contracts.

collected in premiums at the beginning of the campaign. That measure, named loss ratio, is the main indicator of the sustainability of the offer. By deteriorating the loss ratio, adverse selection is making the policy loss-making for the insurer leading to a permanent increase of the premium to compensate 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. On the 2005-2018 period, the loss ratio is on average 101% reflecting a structural loss for the insurers.

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 an important part of the French farmers meaning that they may rely on disasters payments exclusively, whereas the scope of intervention of this public aid is gradually being reduced. Secondly, they imply a poor quality of pooling that threatens sustainability of the offer.

On March 2^{nd} 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] From January 1^{st} 2023, the subvention rate will increase from 65% to 70% and the basic level of the deductible will be decrease to 20%. This law also implements a "one-stop service desk" for farmers which will pay out the compensation from both insurance contract and disaster scheme.

2.2 Literature review

The insurance literature related to crop or 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) and has been adapted to the agricultural insurance framework in 80's by Ashan et al. (1982), Nelson and Loehman (1987) or Chambers (1989) among others. This theoretical framework highlighted the imperfections on this market and its non-optimal character. The public intervention is thus necessary in order to correct this asymmetry, support the development of the market through subsidies or even provide public offer when there is lack of private one. The empirical and analytical literature on this topic has been historically mainly focus on the American market.

More particularly, a literature also developed on the determinants of the crop insurance. Niewuwoudt and Bullock (1985) analysed empirically the determinants of the crop insurance demand using state data on the 1960-81 period from the Federal Crop Insurance Office. They find positive and significant effects on adoption of crop specialization, expected rate of return and expected risk, farm size, disaster payments

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

[3] Loi n° 2022-298 du 2 mars 2022 d'orientation relative à une meilleure diffusion de l'assurance récolte en agriculture et portant réforme des outils de gestion des risques climatiques en agriculture. JORF n°0052 du 3 mars 2022.

and part ownership. From this paper, the crop insurance purchase has been analysed and tested at different states of the market development in the US (Goodwin, 1993; Connor and Katchova, 2020), in different countries in Europe such as Spain (Garrido and Zilberman, 2008), Netherlands (van Asseldonk et al., 2002) or 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) or China (Wang et al., 2016; Lyu and Barré, 2017).

A more recent part of the economic literature around crop insurance is focusing on the effect of farmers' risk attitude on crop insurance purchase decision. Zhao et al. (2016, 2017) showed, with survey data, that farmers' risk-aversion affects positively and significantly the probability to purchase crop insurance. Meanwhile, they find an adverse selection effect as high-risk farmers are more likely to adopt crop insurance. However, they suggest that "substantial" crop insurance subsides will bring even risk-neutral farmers on the market and make it also profitable for less risky-farmers. Yanuarti et al. (2019) also find that farmers have a relative high-level of risk-aversion and it 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 affect this effect. According to their result, if the insured amount is high enough, risk aversion no longer affect the insurance purchase decision.
According to Sitkin and Pablo (1992) and Cho and Lee (2006), the two mains components of behavior are risk attitude and risk perception (the personal assessments of probability to be subject to a specific hazard and losses associated). Menapace et al. (2013) stand that a positive relation between risk-aversion and risk-perception exists such as "*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 asses the effect of both risk attitude and risk perception on crop insurance adoption. Their result suggest that only risk attitude, and not risk perception, is affecting farmers in their decision process. They also identify two types of farmers profiles. The farmers "willing to take risk" and the risk-averse farmers. The first ones are more likely to apply *ex-ante* risk management tools such as insurance or diversification while the others are more into an *ex-post* strategy in which they will face the losses impacts by looking for off-farm income, drawing into their savings or work harder to compensate.

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

French case has been studied with FADN (Farm Accountancy Data Network) data on the 2002-2006 period, corresponding to the period preceding the MRC implementation, by Enjolras and Sentis (2011) who find that largest farms tend to insure more than smaller farms. Also, the farms considered as "high risk" are more prone to subscribe crop insurance contract. Finally, authors underline a "fidelity to insurance", meaning that farmers who already subscribed policy and who received indemnities previously are more likely to subscribe again. Enjolras et al. (2012) made a common approach for France and Italy regarding the main determinants of crop insurance adoption and its elasticities of demand on the 2002 to 2007 period. They confirm for both countries the existence of a "fidelity" or "inertia" effect regarding crop insurance participation. 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 around crop insurance in France was about its effect on farm management and especially on pesticide use. Möhring et al. (2020) find that crop insurance adoption is significantly associated with an increase in pesticide expenditures. Both tools are linked by an intensive and extensive margin effects referring to both an increase of pesticide use per hectare and a cropland extension. Over the 2008 to 2012 period, Enjolras and Aubert (2020) find no specific impact of crop insurance on pesticide use for fields crops and quality wine-growing. Although, they find that crop insurance leads to a reallocation

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

of land within the farm.

Crop insurance is an old topic in agricultural economic literature. Though, the context of the country and the moment of the study are important considerations regarding the results. The different crop insurance schemes mentioned in the literature had 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. Also, the empirical literature has been focusing on determinants to crop insurance, mostly using European or American scale data. We consider it could be relevant to look at barriers to crop insurance adoption. Barriers are not necessarily negative determinants, it could also be elements blocking the functioning of the scheme or being intrinsic characteristics of its design. In addition, to address this question, we propose to collect farmer's data through a survey.

We can categorize the variables studied by this literature into four groups: farms 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 some research hypothesis presented in Table 1.

Table 1: Research hypothesis from the literature.

H1		**Farms 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 is reducing 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 level are less insured than the others.
	H2b	Household size (i.e having in charge children) reduces the likelihood of purchasing insurance.
H3		**The past crop insurance choices of the farmers significantly impact the current insurance adoption.**
	H3a	There is a "fidelity" effect when you were insured to insure again.
	H3b	Having already received compensation from an insurer will encourage to insure again.
H4		**Behavioral variables significantly impact the crop insurance adoption.**
	H4a	The higher the risk aversion, the higher the probability to adopt crop insurance.
	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 she will insure.

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

3 Methodology approach

In order to test theses different hypothesis we needed information we could not find in any data set existing as far as we know. Therefore, we designed an online survey using different methods to question farmers on their crop insurance perception and adoption. In this section, we first describe our design and the sample. Then, we explain our econometric approach.

3.1 The design of our approach

The survey has been spread through the French Chambers of Agriculture network, a group of public organization driven by elected professionals from agricultural syndicates which represent French farmers and rural areas. We aimed to spread the survey among farmers in Metropolitan France regardless of culture or localisation. 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 mails and phone calls. In order to respect anonymity rules, we asked them to diffuse in their respective mailing list or newsletters the presentation and link to complete the survey we provided them. Therefore, as we don't know especially which offices spread it or not and among how many people, we are not able to tell how many farmers received this survey in their mailbox. However, we received responses from 25 different departments among which 4 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. Anonymisation of our survey had made 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 complete survey to the Association "Petits Princes"[5] as Ginder et al. (2009) did for their survey in northern Illinois.

The survey is composed of 57 questions but none of the farmers answer the 57 questions since some of them are 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 tried to design our survey in order to prevent from casual self-administered questionnaires 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 randomised when possible in order to reduce speeding (i.e., giving answer 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). Also, we separate questions in several groups, each on a different step of the survey, so that the respondent will not see the impact on the progress of the survey of her precedent responses. Some responses could open others questions or, on the contrary, not to make them visible to the respondent. In order to prevent the respondent to change her mind because of the emergence of new questions, we have hidden, as much as possible, these decisive questions by putting them on a different stage 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 respondent.

We combine several methodologies to fully answer our research question. Through classical survey questions, we collect socio-demographic variables and characteristics of the farm. Among these questions, we have information related to the farmers' crop insurance. In addition, we use experimental test to quantify risk preferences, self-ranking to measure the subjective degree of impatience, impulsiveness and exposition 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 want to capture as many as possible of the potential explanatory variables.

3.1.1 Classical survey questions

We ask the subjects to indicate if they have (or will) take out crop insurance for the 2020-2021 campaign (Insurance). We ask them if they are insured in the last campaign (InsT1), two years ago (InsT2) and the total number of years of subscription to a crop insurance contract (YearsIns). The last question ask them if they have already received compensation for crop loss from an insurer. As the 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.

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

We can observe that our sample is well-balanced, since 49.31% of the farmers has an insurance contract (142/288). 126 of them have at least a MRC contract, 14 have a hail one, 1 a grassland contract and 1 a revenue insurance. In addition, approximately half of the sample has an insurance contract in the last campaign and two years ago. On average, the farmers in our sample spent 7.7 years with a crop

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

insurance contract, and 55.21% of the farmers have 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 in T were insured the years before. In a similar way, lots of insured have already received compensation from an insurer whereas it is the case of only 26% of the non-insured. Consequently, we expect that such variables impact insurance adoption.

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

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 %
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 out of farm	53.82	57.75	50
	(2) = Spouse doesn't work out 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

In our sample, farmers have on average 49.65 years and they are mainly man. Approximately 10% are located in North of France, 29% in the West, 23% in the East and 36% in South. The household is composed mostly by 2 persons or 4 or more persons. We observe a large heterogeneity concerning the income with more than 70% of the sample between €1000 and €4000. For more than half of the farmers, their spouses are working out of the farm. Finally, 40% of them perceive income from non-agricultural activity.

The surface of the farm is on average 98.13 hectares.[6] On average, respondents are managing their farm since 20.51 years. There is a variety of possible combinations among cultivated crops, however, certain profiles are more represented. Among our respondents, 28.82% are only wine producers, 27.43% are only fields crops producers, 17.36% are producing both fields crops and breeding, 9.03% makes only breeding. 29.17% of the farmers use irrigation, 28.47% are in a contractualization or integrated supply chain approaches, 78.47% are part of a farm cooperative and 57.64% are members of an agricultural union. Most of the farmers are owner and tenant (63.54%), and for 71.88%, the farm was previously manage by a family member. 36.46% of the farm 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 crop. 48.61% of the farmers have already received disaster payment, and 65.97% have suffered from a yield losses due to weather events in the last 2 years.

[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 and little farms group represents respectively 20% and 7% of it (INSEE).

Table 4: Farms characteristics

Variables	Detail	All	Insured	Non-Insured
Surface	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 manage by a family member	71.88	79.58	64.38
Label	Certification	36.46	42.25	30.82
WorkForce	Working with others on farm	51.04	57.04	45.21
Nitrogen	Nitrogen supply to crops	83.33	88.73	78.08
Disaster	Already received 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

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 choose 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). Each farmer faces the nine gambles presented in the first three columns of Table 5 and we ask her to choose the gamble that she accepts to play for. Each gamble is a fifty-fifty gamble with 50% chance to obtain payoff 1 and 50% chance to have payoff 2. The choice is purely hypothetical, there is no incentives.[7] The choice of a gamble allows to infer an interval for the relative risk aversion coefficient (column 4), from "extremely risk averse" (RA5) to "highly risk prone" (RP3), through risk neutral (RN) (column 5). The higher the number is, the higher the intensity of the individual's preference is. A coefficient equals to zero means risk neutrality while a positive one indicates risk aversion and a negative one represents a risk prone behavior.

The last three columns of the 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. We also compute the average risk aversion coefficient of the whole sample that 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).

[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 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 exposition to weather hazards

Patience is here use as a proxy for time preferences measurement. Using an ultra-short and self-measure of this parameter has been tested and validated by Vischer et al. (2013).
Impulsiveness is controlling along side patience behavioral factors that could affect a decision. Impulsiveness isn't use as a proxy to time preferences but it can captures the effect of triggering elements that can explain a specific behavior (purchase or decision) (Vischer et al., 2013).

Consequently, we use two self-assessment scales, one to estimate the degree of patience and the other for impulsiveness. The scales are from 0 to 10 with 0 corresponding 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 farms exposition to weather hazard, we use a 5 self-ranking scale from 0 "very little exposed" to 5 "very strongly" exposed.

Table 6: Impatience, Impulsiveness and Exposition

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)
FarmExposition	0=very little to 5=very strongly	3.31 (0.98)	3.47 (0.9)	3.15 (1.03)

On average, the farmers are patient (5.98/10) not so much 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.

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

For the barriers, we ask 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.

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 represented. Some differences between the insured and the non-insured also appear concerning variables like *BarrierPROB* and *BarrierINCO* where more than 1 point difference exists between the two sub-samples.

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 problem	3.42 (1.1)	3.29 (1.2)	3.54 (1)
BarrierADMI	Too much 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)

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

Using a ranking methodology has been previously done in a self-administered survey on crop insurance issue by Ginder et al. (2009). Consequently, in order to identify the determinants to insurance adoption, we ask the insured respondents (n=142) to rank the first three proposals (TOP3) that most encourage them to insure among the following ones: bad weather forecasted / anticipated, external councils (cooperative members, neighbours, 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 ask the non-insured respondent (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 hypothesis and assumption we made.

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

3.2 Econometric strategy

According to the literature and our assumption, we expect to explain the crop insurance adoption through a model as follows (see Enjolras and Sentis (2011) for a similar presentation):

$$\begin{aligned}\text{CropInsurance}_i = \beta 0 &+ \beta 1 \text{ Past experience with crop insurance} \\ &+ \beta 2 \text{ Farm characteristics} \\ &+ \beta 3 \text{ Farmers characteristics} \\ &+ \beta 4 \text{ Behavioral measures} \\ &+ \beta 5 \text{ Perception of contract characteristics } + \epsilon \text{i}\end{aligned}$$

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

In a first step, we process the cross-sectional data from our survey through two probit models. As our approach is based on the analysis of barriers to insurance adoption, we first regressed our variable of interest with our 13 Likert measures associated to the different barriers presented in Table 7 (model (1)

presented in Eq. (1)). Then we process to add all the control variables and parameters at our disposal (model (2) presented in Eq. (2)).

$$Pt(y = 1) = F[\beta Zt + \epsilon i] \tag{1}$$

$$Pt(y = 1) = F[\rho Xt + \gamma Wt + \zeta Vt + \beta Zt + \epsilon i] \tag{2}$$

where y is the binary variable on crop insurance adoption, Xt is a vector of farms characteristics (see Table 4), Wt is a vector of farmers' characteristics (see Table 3), Vt is a vector of behavioral variables (see Tables 5 and 6) and Zt is a vector of the potential barriers to insurance adoption (see Table 7).

In a second step, we adopt a dynamic analysis approach to the adoption of crop insurance. 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 set of parameters (area, participation in a cooperative or trade union, family situation, measures of behavioural variables, etc.) to be constant over the three years studied. Using this database of 864 observations (288 individuals over 3 years), we perform a dynamic probit model. We estimate 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:

$$y^*it = \gamma Z_{it} + \rho y_{it-1} + C_i + u_{it} \tag{3}$$

with

$$C_i = \alpha_0 + \alpha_1 y_{i0} + \alpha_2 \bar{Z}_l + \alpha_3 Z_{i0} + ai \tag{4}$$

where yit 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 strictly exogenous, conditional on the unit-specific unobserved effect C_i, u_{it} is the idiosyncratic error term. y_{i0} and Z_{i0} are, respectively, the initial value of the dependent variable (crop insurance) and of the time-varying explanatory variables. $\overline{Z}_l = \frac{1}{T}\sum_{i=0}^{T} Z_{it}$ is the time-averages of the explanatory variables, ai 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 did collect aggregated climate data for the years 2017, 2018 and 2019. Thus, we complete 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*). As 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 analyse our result in two steps. In a first time, we present the results of the econometric strategy dealing with the determinants and barriers to the adoption of crop insurance contract. In a second time, we focus on adopters (of insurance contract) on one-hand and non-adopters, on the other hand, and the variables that support them in their choice. The first step will test through econometrics 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

Table 8 presents the results of the two simple probit regressions (models (1) and (2)) and Table 9 presents the results of the dynamic probit regression (model (3)). We begin with the interpretation of Table 8.

Table 8: Results of the simple probit regressions.

	Crop Insurance adoption	
	(1)	(2)
BarrierPRICE	−0.201*	−0.309
BarrierDED	0.263**	0.586**
BarrierTRIG	0.322**	0.323
BarrierSHIFT	0.060	0.191
BarrierADMI	−0.177**	−0.193
BarrierINCO	−0.293***	−0.314**
BarrierPROB	−0.563***	−0.655***
BarrierYIELD	0.176	−0.022
BarrierPREV	−0.035	−0.243
BarrierTRUST	−0.111	−0.434**
BarrierDIVE	−0.265***	−0.128
BarrierCOMP	−0.129	−0.309**
BarrierEARLY	0.082	0.176
TypeAgri		
1.Field Crops (FC)		0
2.Wine		0.796
3.FC and Breeding		0.739
4.Breeding		−1.241
5.Diversified-other		0.366
Surface		0.003
Localisation		
1.North		0
2.West		−0.668
3.East		−1.615**
4.South		0.498
Irrigation		−0.291
Contract		−0.761**
Coop		1.831***
Syndicate		−0.347
FarmExp		−0.025
FamilyFarm		0.430
Label		0.833*
WorkForce		0.627**
Nitrogen		0.044
Disaster		0.310
RecentLoss		1.51***
Compensation		2.21***
Age		0.018
Gender		0.873*
HouseholdSize		−0.170
Tenure		
1.Landowner		0
2.Tenant		−1.545**
3.Tenant-Owner		−0.843**
SpouseOccupation		
1.Single		0
2.Yes		−0.903
3.No		−1.086*
Income		
<1000		0
[1000:2000[		1.521**
[2000:3000[		1.273
[3000:4000[		1.421
[4000:5000[		1.386
>5000		0.542
No answer		1.791*
NonAgriIncome		−0.069
FarmExposition		0.20
CoeffRA		−0.02
Patience		0.131*
Impulsiv		0.043
Constant	2.313***	−3.071
R^2	0.3581	0.6944
Observations	288	288

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

Table 9: Results of the dynamic probit regression.

	Crop Insurance adoption
	(3)
L.Insurance	3.115***
BarrierPRICE	−0.276
BarrierDED	−0.055
BarrierTRIG	0.586**
BarrierSHIFT	0.091
BarrierADMI	−0.122
BarrierINCO	−0.152
BarrierPROB	−0.697***
BarrierYIELD	0.048
BarrierPREV	−0.075
BarrierTRUST	−0.302*
BarrierDIVE	−0.106
BarrierCOMP	−0.010
BarrierEARLY	0.060
Surface	0.004*
Irrigation	−0.145
Contract	−0.261
Coop	1.140**
Syndicate	−0.074
FamilyFarm	0.170
Label	0.484
WorkForce	0.524
Nitrogen	0.025
Disaster	0.012
Compensation	0.683*
Gender	−0.221
HouseholdSize	−0.063
Tenure	
1.Landowner	0
2.Tenant	−1.598**
3.Tenant-Owner	−1.010**
SpouseOccupation	
1.Single	0
2.Yes	−0.165
3.No	−0.839
Income	
<1000	0
[1000:2000[	1.694**
[2000:3000[	1.316*
[3000:4000[	1.430*
[4000:5000[	1.940*
>5000	1.073
No answer	1.482
NonAgriIncome	0.167
FarmExposition	0.165
CoeffRA	−0.013
Patience	0.068
Impulsiv	0.080
Min. Temperature	−0.216
Max. Temperature	0.254
Total Precipitation	−0.002
Total Sunshine	−0.009*
Max. Wind gust	0.075
Constant	−31.002
Observations	576
Number of groups	288

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

In the first model in Table 8, we test the effects of the barriers to insurance adoption. We observe that the barriers perception alone lead to a R^2 of 0.35, already explaining one third of the insurance adoption. Among the thirteen potentials lock-ins 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 too 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 understand well the implication of the contract characteristics and underline 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 not insure is made before they even look at the different terms of the contracts. The five others barriers proposals have a negative and significant impact on insurance adoption. Thus, the too high price ($BarrierPRICE$), too much 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 disincentive to insurance adoption. The cost of insurance is naturally the biggest lock-in for the farmers. As we will see later, 171 farmers ranked this proposition as one of their TOP3 lock-ins. The purpose is to see above this first step and to look at the specifications of the contract proposed at this cost. Also, the administrative management of the crop insurance contract is a significant barrier for the adoption. If insurance is too costly in terms of time and required information, the farmers are discourage to insure. The fact that the decision to insure could be too early for the farmer's campaign seems to be also a determinant. Considering herself diversified enough is a major element explaining the non-subscription to the insurance scheme which had notably also been highlighted by Falco et al. (2014).

Introducing the other variables in model (2) improve the adjustment with a R^2 of 0.69. In model (2), the effect of the barriers is a little bit modified since the variables $BarrierTRIG$, $BarrierADMI$ and $BarrierDIVE$ become no more 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 lock-in "Trust" which means that not trusting insurer affects negatively the likelihood of insurance adoption. This result is intuitive. In addition, as shown in Fig. 2, non-insured rank this notion of trust much more in their TOP3 barriers.

Concerning the other variables tested, we find no specific effect of the different typologies of agricultural activities that we tested. Our sample is highly composed by wine growers and field crop producers, both being the most insured as compared to the other types of farmers. The localisation has a significant impact only for farmers in eastern part of 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 farms characteristics, we observe that the surface has no impact as well as the use of irrigation or nitrogen. However, having a certification ($Label$) and working with others on farm ($WorkForce$) have a significant and positive effect on insurance adoption. In the same way, having suffered from a 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 the insurance adoption.

Finally, we show that some farmers' characteristics also impact the insurance adoption. In particular, the tenure seems to be important. Indeed, being tenant or tenant-owner (as compared to landowner) significantly discourages the farmer to insure. The fact that the spouse doesn't work out of farm also represents a significant disincentive to insure. The income level is also determinant. We find that farmers with monthly income level between €[1000-2000] have a higher probability to insure than those with less than €1000. The non-significance of the higher levels seem to indicate that income lower than €2000 encourage to insurance adoption. The last significant variable is the degree of patience. We find that the more patient the farmer think she is, the more likely she will subscribe to crop insurance which fits with the economic literature around time preference, discount rate and insurance demand (Hill et al., 2013). We find no significant effect of risk aversion and impulsiveness measures on crop insurance adoption.

Now, if we look to Table 9, we observe that some results are similar to those presented in Table 8. This is the case for the variables $Tenure$, $Compensation$ and $Coop$. However, some differences appear too. The variable $Surface$ is now positively significant meaning that the higher the farm, the higher the incentive to adopt insurance contract, which is in line with Enjolras and Sentis (2011). Almost all the income classes have a positive and significant impact on insurance adoption (except the higher one). This means that not belonging to the lower income class (<€1000) encourages the farmer to insure. The barriers being significant are also different: $BarrierTRIG$ has a positive effect whereas

BarrierPROB and *BarrierTRUST* have a negative one. Concerning the instrumental variables, only the annual cumulative sunshine has a significant and negative effect on farmer's 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 find that the variable *L.Insurance* is positive and highly significant reflecting an inertia for previously insured farmers.

4.2 Adopters versus 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 scale relative to the proposed obstacles to the adoption of crop insurance. After this step, respondents had to classify in the survey their TOP3 among these proposals (Table 7). Looking at the rankings according to the fact of being insured or not (Fig. 2) provides additional information about their relative perception of the crop insurance scheme and its characteristics. The following figure (Fig. 2) represents the occurrences of answers as top 1 (dark grey), top 2 (grey) and top 3 (light grey) among the propositions of main barriers to crop insurance adoption for both insured(i) (n=142) and non-insured(n) (n=146) respondents.

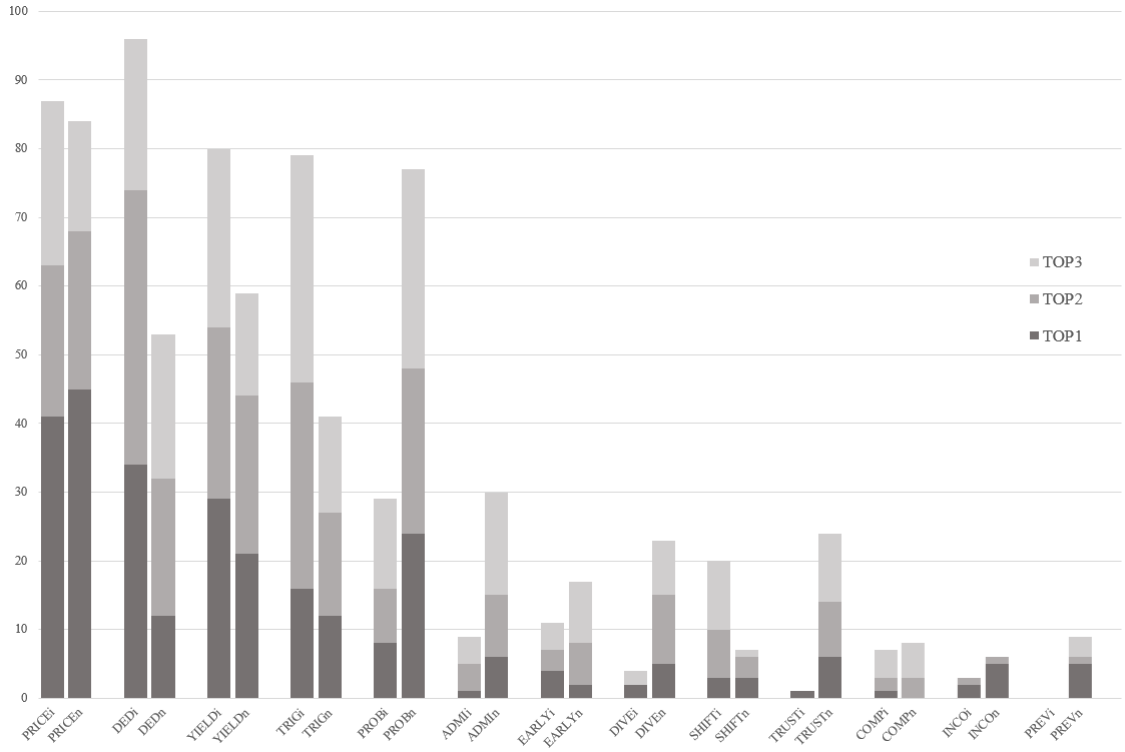

Figure 2: Main barriers to crop insurance adoption for insured (indexed i) and non-insured (indexed n)

It appears that insured and non-insured do not rank in the same order the lock-ins propositions. For both population 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 while it is ranked as fifth place 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 as important barriers, especially for the insured population. The deductible level proposal, even though collecting less first ranking, has a higher recurrence in the global TOP3 classification of the insured.

As expected, we find more recurrence of the proposals relative 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 relative to the subscription and then the application for the subsidy is much more classified as a top barriers for the non-insured than for the insured (which confirms the sign

and significance of *BarrierADMI* in Table 8).

4.2.2 The determinants of adoption (or entry)

In this following part, we use the third group of questions surrounding determinants of crop insurance adoption. Figures 3 and 4 respectively represent the classification made by crop insurance adopters regarding elements that convinced them to insure and non-adopters on potential changes that could convince them to adopt crop insurance. Both figures represent the occurrences of answers as top 1 (dark grey), top 2 (grey) and top 3 (light grey) among the propositions.

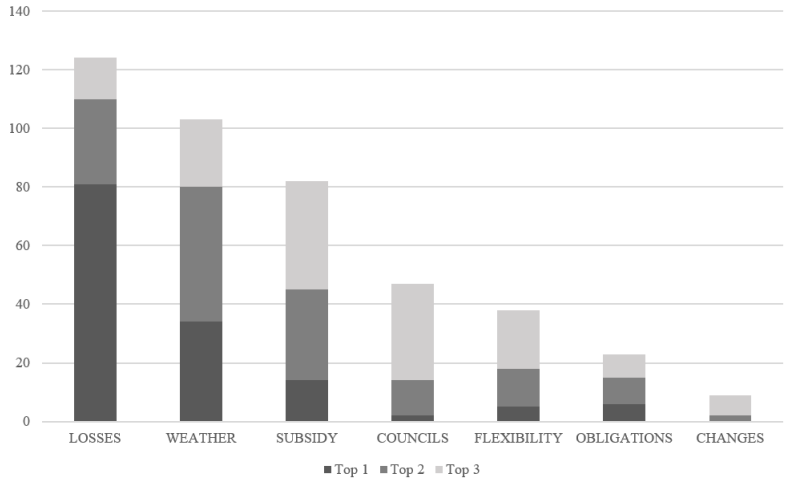

Figure 3: Factors encouraging crop insurance adoption.

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

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. In total 104 out of the 146 non-adopters, placed this proposition in their TOP3 among who 58 ranked it as the first factor. It appears important to link this proposition with the propositions on the level of *Direct Subsidy* and its payment modalities. An increase of the subsidy or a decrease of the premium should be seen as substitutes but our result suggest that it doesn't appear as it for farmers. It is probably partly due to the modality of payment of the subsidy. In addition to impacting cash flow, particularly for smaller farms, the time lag between payment of the premium and receipt of the subsidy has an impact on farmers' 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 as 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[8] appears as a major features 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*)[9] is the main factor (after *Premium*) that could attract non-adopters to adopt insurance.

[8]This proposal was also taking into consideration the triggering threshold, as it was presented as a "A lower deductible and threshold for triggering compensation".

[9]Usually as the same level. Triggering threshold could be higher than deductible but not the opposite.

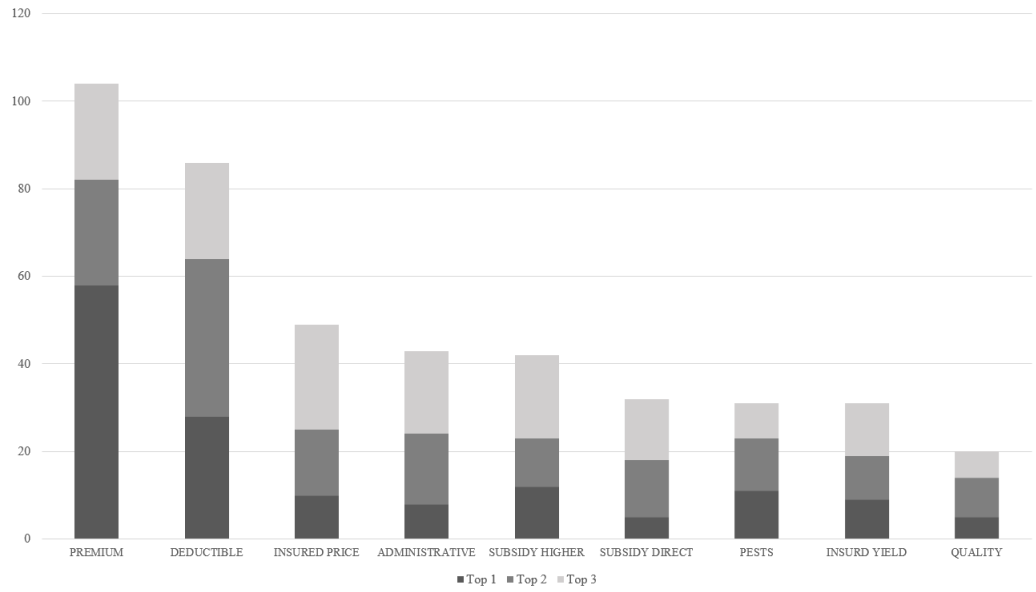

Figure 4: Potential entry factors in the crop insurance market.

Even if these parameters are more declared as an issue for the insured population (Tables 8 and Table 9), reducing the level of both parameters should attract hesitant farmers to insurance. The *Insured price*, controlled by an official chart appears to be more an issue than the *Insured yield* modality (based on an "olympic" average). *Pests* and *Quality* coverage are among the last propositions. More data and deeper analysis would be necessary around theses two propositions. We expect theses parameters being more important for fruits and vegetables growers who are not enough in our sample and who are the least covered by crop insurance contract even if they produce the most weather-sensitive products.

5 Discussion

5.1 Summary of the results

To sum-up our result and review our hypothesis, we find 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 find that crop insurance is less adopt by farmers with lower income level (**H2a**) and we find a significant and positive effect of the farm size (in hectare) in model (3) (**H1a**). We find no effect of household size (**H2b**) on the likelihood of crop insurance purchase. Regarding behavioral variables, we do not find a significant effect neither for risk aversion (**H4a**) nor for risk perception (**H4b**). Time preferences, that we assess with the patience measurement, is influencing crop insurance adoption (**H4c**) as 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 on the contract characteristics affect significantly their decision and it exists intrinsic brakes in the design of the scheme such as the administrative burden associated and the incompatibility of the proposed contracts with the growing calendar.

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 compensate high enough?* This first step is highlighted by the importance of the expected weather in the factors influencing insurance take-up (Fig. 3), the perceived probability of compensation in Fig. 2, and the significance of the variable *BarrierPROB* in our models (Tables 8 and 9). As crop insurance is not mandatory as 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 to compensate. Trust is more an issue for the non-insured than for the insured (Fig. 2) which seems counterbalanced by experience with crop insurance and particularly 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 gives information on the level of compensation for a given loss.[10] The deductible level appears as a major element of consideration for farmers as show 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, tells the part of the damaged not compensated and thus, the level of loss above which compensation will be paid (as deductible and triggering threshold are usually at the same level, we suspect a mix-up 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 (Fig. 2 and 4). Insured price 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 did implement important subsidies. However, this principle of interchangeability between a reduction of the premium and a raise 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 doesn't stand out significant in our model, we find with an analysis of the brakes according to income groups that it is especially an issue for farms with the least cash flow capacity and could be an explanation to the lowest adoption rate in the field of fruits where the high-value and vulnerability of the crops induce a high level of premium per hectare. Also, crop insurance expenses fit in a global risk management allowance. Thus, farmer 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 more important for the non-insured (Fig. 2) and the variable *BarrierDIVE* affects negatively and significantly the likelihood of crop insurance adoption (Table 8, model (1))). As all the efforts and investments made for prevention are not valued by a reduction in the level of premium even though it decreases the risk-exposure of the farmers, this kind of instruments are substitutes to crop insurance from the farmers' point of view.

This whole line of reasoning is influenced by the farmers profile. As previously said, 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 would assign a farmer with a strong preference for present. Risk perception, impulsiveness and risk attitude have not a significant effect on the likelihood to purchase crop insurance.

5.2 Public policy implications

Three degrees of risks are usually considered corresponding to the OECD approach in regarding 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 transfer to an insurer if it meets the insurability criteria and a catastrophic risk, infrequent bringing high damage on production and impacting a lot of farmers for which a public intervention is required. French government is currently considering this three-layer approach[11] and adapting its risk management policy in agriculture by proposing and subsidizing different tools. Relatively 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 aiming at reducing the probability of occurrence of the damage, like hail nets, anti-frost devices or irrigation system can be subject of public investment aid. Similarly, French government promotes self-insurance tools aiming at reducing

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

[11] Draft law n°4758 reforming the tools for managing climate risks in agriculture, December 1^{st} 2021.

the damage in case of risk occurrence. For example, the government encourages precautionary savings through tax deductions with the *"Déduction pour épargne de précaution (DEP)"* which allows to place on a specific account a share of the annual profits 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 synergy and complementarity of these tools with crop insurance. National strategy sets out this three-layers approach, each layer being 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 complementary which is actually 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[12] states on these two points. First, the next set of specifications drawn up by public authorities will fix measures and practices that are supposed to decrease premium level if implemented by the insured. Then, the complementarity between crop insurance and disaster scheme is defined by a threshold of compensation. According to the size of the losses, farmers will be compensate 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 deductible level is a major parameter regarding crop insurance contract especially for already insured farmers. Farmers perceive it as main barrier and it seems to make adoption less attractive as it was still ranked as second major barrier by the non-insured respondents. The incoming reform (to be applied from January 1^{st} 2023) introduces a reduction from 30% to 20% of the deductible level for the basic contract MRC. In their evaluation report, Boucher et al. (2019) state that the deductible reduction option is quasi-systemic for the MRC subscribers but implies an important rise of the premium as going from a 25% to a 20% level implies, according to their estimation, to a 40% surplus of premium (40% subsidy rate is eligible on this surplus). The standardisation of the 20% rate may attract more farmers and will be included in the main subsidy rate.

The reform also implements a measure originally intended in the OMNIBUS regulation[13] by raising the main subsidy rate from 65% to 70%. This increase of the subsidy is supposed to encourage adoption. However, even if the amount of the subsidy is important, 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 applied directly when paying the insurance premium as it is the case in Spain for example. Public authorities may consider the creation of an entity in charge to handle this time lag, like AgroSeguro in Spain.

The stated goal of public authorities is to expand as much as possible the insured pool 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, however, there is no evidence of major changes in the less insured crops that would encourage them to enter the market. Since its implementation, MRC contracts have never convinced the fruits growers and additional and specific studies on this field seem necessary. It seems 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 relating to the compatibility of their situation and the lack of need and trust for insurance cover. More widespread information on available offers and greater adaptability of these could convince new farmers to enter the market.

Our results imply an inertia effect in the 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 implement 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 result, 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

[12]Loi n° 2022-298 du 2 mars 2022 d'orientation relative à une meilleure diffusion de l'assurance récolte en agriculture et portant réforme des outils de gestion des risques climatiques en agriculture. JORF n°0052 du 3 mars 2022.

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

contract toward pests, diseases and insects 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 pests risks. As these risks are also major concerns for farmers, the extension of insurance coverage could attract new policyholders and improve the quality of mutualisation. The proposal *PESTS* doesn't appear in the top proposals of potential entry factors (Fig. 4), but we suppose it would be ranked higher if our sample was composed with a higher proportion of fruits and vegetables growers.

6 Conclusion

This paper is part of a debate in France (but also in other European countries) on the reform of the crop insurance scheme. In particular, since the current scheme gathers only 30% of the agricultural surface, the question of the determinants and barriers to the adoption of insurance contract is relevant. To address this question we propose an original survey approach combining different methodologies in order to capture as many as possible of the potential explanations. In this context, we confirm some existing effects (recent loss, income, 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 to collect 288 full answers but at the beginning we expected more. Deeper analysis could have been made if more responses were collected. Because of our sample size, we were not able to analyse more the crop insurance adopters. In particular, we have variables regarding the type of contract and the various options the farmers subscribed, but we can not use these information in this article. It would have been interesting to look at the difference of contract adopted regarding risk perception and preferences and also look at the difference of choices made between farmers who voluntarily subscribe and those who subscribe to respect contractual clauses. Also, a main issue regarding the current French crop insurance scheme is the important inequalities of coverage between crops. Unfortunately, we were lacking responses from fruits and vegetables growers who are the less insured and who are among the most exposed to weather 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 proved the role of ambiguity aversion in an insurance context both experimentally and theoretically (Kunreuther et al., 1995; Alary et al., 2013). In addition, the farmer's ambiguity aversion has already been quantified, including for French farmers (Bougherara et al., 2017; Tevenart and Brunette, 2021). However, the link between farmer's 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 farmer's behavior. In this sense, experimental measurement of ambiguity preferences based on MPL approach has been proposed by Chakravarty and Roy (2009), and may be helpful. Second, we can consider including loss aversion, considered in Prospect Theory (PT) (Kahneman and Tversky, 1979). Indeed, some articles show that French farmers behave, almost partly, 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 to consider the probability weighting that refers to 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 hold particularly interesting avenues for future research.

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A Appendix A. Development of the MRC policy since 2005

Table 10: Development 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 French Ministry of Agriculture and from Budget Bill 2022: Agriculture, food, forestry and rural affairs.

B Summary of the results of the literature

Table 11: 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.