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Green Insurance for Pesticide Reduction: Acceptability and Impact for French Viticulture

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Marianne Lefebvre^a
Niklas Möhring^f

Yann Raineau^{b,c}
Pauline Pedehour^a

Cécile Aubert^{c,d,e}
Marc Raynal^{g1}

Abstract

Green insurance can help producers manage the risks of transitioning to more environmentally friendly practices. We investigate the uptake determinant and potential pesticide reduction in the viticulture sector, a major pesticide user, using a choice experiment with 412 French growers. Correcting for sampling bias, we find that between 48% and 60% (depending on contract features) are likely to take up green insurance. The insurance offers compensation for yield losses caused by the failure to contain diseases of a Decision Support System targeting pesticide reduction. We find an average 45% reduction in fungicide use for adopters and conclude that green insurance can be a cost-effective tool for achieving the EU's ambitious pesticide objectives.

JEL codes: Q18, Q14, D81, C99

Keywords: Choice experiment, Pesticides, Viticulture, Insurance, Decision Support System, Integrated Pest Management, Index, Mutual fund.

¹a: Univ Angers, GRANEM, SFR CONFLUENCES, F-49000 Angers, France, b: INRAE, ETTIS, F-33612 Cestas, France, c: Univ. Bordeaux, CNRS, BSE, UMR 6060, F-33600 Pessac, France, d: Toulouse School of Economics (TSE), e: GAEL, U. Grenoble Alpes, f: Production Economics Group, University of Bonn, g: Institut Français de la Vigne et du Vin (IFV), UMT SEVEN.

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²Coordinated by the Regional Council of *Nouvelle-Aquitaine* (southwestern France, a region that includes the Bordeaux and Cognac vineyards) and co-financed by the French government through the “Territoires d’innovation de grande ambition” program (High-ambition innovation territories), VitiREV is an action plan covering the period 2019-2027, co-constructed by a collective of over 150 partners from the *Nouvelle-Aquitaine* wine sector, to meet the challenges of ecological transition and climate adaptation.

1 Introduction

Pest management is central for ensuring crop yield and quality (Savary et al. 2019) and its importance is expected to further increase under climate change (Chaloner, Gurr, and Bebbler 2021). Current pest management strategies are mainly based on pesticide use, with increasing evidence of pesticides' adverse effects on the environment and human health (IPBES 2019; Geiger et al. 2010; Edlinger et al. 2022; Willett et al. 2019; Snelders et al. 2012). As a consequence, reducing pesticide use and risks has become an important public policy goal on regional and global levels (Möhring, Ingold, et al. 2020 ; Möhring, Kanter, et al. 2023).

Decision support systems (DSS) for farmers to optimally time applications according to actual local disease pressure have the potential to reduce pesticide use while maintaining yield levels (Pertot et al. 2017; Chen et al. 2020; Anastasiou et al. 2023), and fungicide in particular (Lázaro, Makowski, and Vicent 2021). However, their uptake is often low. One important reason is that expected risks of yield losses are perceived as higher when adapting management strategies (Gent, De Wolf, and Pethybridge 2011; Shtienberg 2013; Möhring, Wuepper, et al. 2020a).

Green insurance, which insures potential yield losses when switching practices, is not currently included in policy toolboxes, despite its potential to increase farmers' uptake of DSS-based crop protection strategies. With green insurance, the insured producer receives financial compensation in case of yield losses caused by the failure of best management practices (here the inability of the DSS to contain diseases). If producers have biased perceptions regarding the effects of new practices on the level and variability of yields or profits (Feather and Amacher 1994), green insurance could help them revise these perceptions by allowing them to try these practices risk-free (Mitchell and Hennessy 2003; C. Aubert et al. 2020). In other domains, it has been shown that sub-optimal insurance levels are observed when agents face an explicit or implicit cost to discover the true probability of losses, but public subsidy can trigger optimal insurance decisions (Kunreuther and Pauly 2004). Compared to agri-environmental schemes (AES), subsidizing green insurance can be more cost-effective since public support is triggered

only for actual losses (Baerenklau 2005), and the level of support required to induce participation by risk-averse producers does not need to include a risk premium.

A few green insurance contracts have been experimented within the US and in Europe.³ But these experiments have only been conducted on a small scale, with no proper measure of cost-efficiency nor evaluation of the levers to increase acceptability. Some authors have modeled producers' decision to contract green insurance (DeVuyst and Ipe C. 1999; Baerenklau 2005; Harris and Swinton 2012), but more empirical research is needed to evaluate its potential uptake and impact. A fundamental challenge is to design insurance products that will be adopted by a large range of farmers, will actually lead to best management practices' adoption and are more cost-efficient than other instruments (Hazell and Varangis 2020). *Ex-ante* evaluation is thus important for industry and policy to develop products and support programs that are attractive to producers. Such (subsidized) risk management tools for pesticide use reduction may have a high global relevance - in the EU as well as beyond (Möhring, Kanter, et al. 2023).

Here we assess the effect of different insurance designs on acceptability, as well as the potential impact of a subsidized green insurance, targeting fungicide use in French viticulture. Grapevine production is globally among the most pesticide-intensive and economically relevant crops, and therefore represents a key entry point to reduce pesticide use in agriculture. In France, the iconic wine production covers only 3.3% of the agricultural area (in hectare) but is responsible for 14.4% of total agricultural pesticide expenses (Butault et al. 2010). Fungicides represent more than 80% of pesticides used on vines in France (measured in Treatment Frequency Index)(French agricultural ministry 2022). Due to their high technical efficacy and low cost, they are sometimes

³For example, in the US, producers who implement voluntary practices to minimize nutrient contamination of surface and groundwater, can be indemnified for yield losses (Harris and Swinton 2012). The same existed in the early 2000s for US corn producers following Integrated Pest Management (IPM) recommendations not to treat with insecticides against corn root-worm, with a similar contract (by IGF Insurance) for potato growers using IPM for potato blight (Mitchell and Hennessy 2003). In Veneto (Italy), corn producers following IPM recommendations can benefit from yield loss coverage in case of recommendations failure, paid by a mutual fund. In France (Nouvelle-Aquitaine), within the VitiREV project, two wine cooperatives have tested such an insurance conditional on the reduction of fungicide use, in very specific conditions including a premium initially entirely covered by public subsidies (C. Aubert et al. 2020). A new experiment has just been launched between a different insurer and a large private wine group, proof of viticulture actors' interest in such contracts.

referred to as a very attractive “insurance”.⁴ We begin with developing a theoretical model to analyse the decisions to subscribe to green insurance and to comply with DSS recommendations (thereby reducing the use of pesticides). We then conduct a discrete choice experiment with 412 French grapevine growers on the uptake and design of the insurance and combine it with field experimental data on the pesticide use reduction potential. We evaluate the acceptability of both loss-based and index-based insurance, since the latter is perceived as having a large potential to contribute to better farm-level risk management and more efficient use of natural resources (Dalhaus, Musshoff, and Finger 2018). Doing so, we contribute to the very narrow literature on insurance covering pest attacks and diseases, which accounts for only 0.9% of the agricultural insurance literature (Vyas et al. 2021).

Adjusting for sampling bias, we find that between 48% and 60% of the vine growers are likely to subscribe to the green insurance, depending on contract design and prices. Producers transitioning to organic certification are more interested in the contract. This result suggests that green insurance could – in addition to intensive margin effects on pesticide intensity – also have extensive margin effects: it could help reduce pesticide use by supporting transitions to organic farming. Clear preferences emerge for contract design: all producers exhibit less interest in group and index-based contracts. Using data from field experiments on the DSS impact on fungicide use, we can estimate to what extent adopters could reduce their number of fungicide treatments. We find an average Treatment frequency Index reduction of 45% at the French level. This result relies on assumptions that are based on the performance of the DSS as observed in Nouvelle Aquitaine and in 2019; the assumptions may be less relevant for other regions and years and should therefore be interpreted cautiously. The chosen set-up would entail higher potential subsidy costs compared to existing policy tools in France, but also a higher pesticide reduction potential. Our results remain valid throughout a series of robustness checks.

This paper is structured as follows. In Section 2, we present the insurance scheme and model

⁴Pesticides are more adequately termed a prevention mechanism (rather than insurance). An insurance improves outcomes in bad states of the world, whereas a prevention tool reduces the probability of these bad states occurring. In the following, we model fungicides as reducing the probability of suffering very low yields because of diseases, in line with the definition of a prevention mechanism.

vine growers' decisions to subscribe to green insurance and comply with its requirements. In Section 3, we explain the DCE approach and describe the experimental setting and methods used for data analysis. Results are presented in Section 4 and further discussed in Section 5.

2 Modelling vine growers' decisions

In this section, we analyze different types of insurances that incentivize the uptake of DSS providing treatment recommendations for vine growing. We identify the conditions under which a risk-averse producer will choose to subscribe to a green insurance scheme, that covers potential yield losses due to fungal diseases in grapevines. The scheme entails free access to a DSS that models and recommends optimal timing of applications based on climatic and fungus pressure information. Without such recommendations, vine growers tend to apply fungicides too early in the season and repeat applications as soon as the previous application has been washed away by rain, whatever the actual disease pressure, leading to over-use of pesticides (Davy et al. 2020). Pesticide use is measured by the Treatment Frequency Index (TFI), i.e. applied quantities normalized by their standard treatment dosage summed up over the course of an agricultural season (Lechenet et al. 2017). We focus on changes in pesticide use per hectare, i.e. intensive-margin effects of the insurance scheme.⁵

If producers follow the DSS recommendations, a public subsidy is added to the indemnity paid by the private insurer.⁶ By subsidizing indemnities rather than the premium, public money

⁵Previous studies have found that risk management tools can also have important extensive margin effects (changes in land use decisions), resulting in effects on producers input use (Möhring, Dalhaus, et al. 2020; Wu 1999; Goodwin, Vandever, and Deal 2004). These studies mostly focus on arable farming. Significant extensive margin effects are unlikely to occur for grapevine production in France, at least in the short- to mid-term. Grapevine production in France is historically very established and follows a plethora of local, regional and national customs, rules and regulations, as well as established consumer preferences, which strongly limit both extending production areas and switching to other varieties. In addition, most adequate soils for grapevine production are already under production. Such rules, regulations, and customs may however evolve, especially in the long run, and risk management tools should then carefully be evaluated with regard to their effects, for example for the decision to plant resistant or climate change-adapted varieties - which is out of the scope of this study. However, note that extensive margin effects comprising switches to different production systems, such as organic production, might be possible in the short- to mid-term, and are considered in our empirical application.

⁶Note that we may be using the term 'green insurance' in a broader sense than some of the literature (DeVuyst and Ipe (1999), Mitchell and Babcock (2002), Mitchell and Hennessy (2003) or Baerenklau (2005)), to the extent that the private insurer covers losses independently from the grower's compliance with the DSS. However, the

is not disbursed for each policy-holder, but only for those suffering a loss.⁷ Directing public support to increase the indemnity is more efficient than reducing the premium (or paying a fixed subsidy as in an AES) when vine growers are risk-averse or pessimistic about losses associated with greener practices since it induces participation at a lower cost. The subsidy provides an incentive to producers to follow the DSS, even when it recommends treating less than they would have originally done, thus reducing the externalities of pesticide use.

We first describe the green insurance contract and then derive theoretical expectations on the impact of pesticide reduction, profits, and the producer’s decision to subscribe to the insurance.

2.1 The features of a green insurance contract

A green insurance contract is characterized by its price P (per unit of insured capital), and the way the indemnity I is computed and granted. The probability of losses is endogenous in a green insurance contract so that we cannot express P using a loading factor.⁸ The indemnity typically does not fully cover losses: contracts entail a deductible, to avoid negligent care (not related to pesticide use, since change in crop protection practices is the target of green insurance). To incentivize producers to reduce fungicide use, the insurance scheme entails a bonus in the form of increased indemnity, financed by public authorities, for vine growers respecting the treatment protocol (timing, dosages) provided by the DSS, and not carrying out any treatment other than those recommended by this protocol. This is verifiable, in the context of our study, since recording data on treatments (date, product, quantity) is mandatory and legal audits take place. To limit moral hazard, insurance contracts also include requirements to provide

bonus indemnity, corresponding to the public part of the insurance, does depend on this compliance, i.e., the bonus indemnity is only paid if there is a failure of the DSS.

⁷In the EU, multi-peril crop insurance premia are subsidized, but compensation rates are considered too low to foster adoption (Descrozaillaie 2022).

⁸In the insurance literature, insurance premia are customarily expressed as a proportion m of the indemnity, where m is the “loading factor” (as in, e.g., Clarke 2016). This factor is 1 for “actuarially fair” insurance (meaning that a risk-neutral insurer makes no profit, as is customarily assumed under perfect competition). This approach assumes that one can compute the expected indemnity (paid ex-post) to assess the corresponding premium (paid ex-ante). In our context however, the probability of losses is endogenous to the contract, since it depends on the incentives of the producer to reduce fungicide use and to follow the DSS. One can therefore not express the price P as a function of I .

full documentation on the adoption of best practices, as well as the right to deny claims when evidence of lack of due diligence is apparent. The objective is to facilitate expert evaluation of losses, in particular, to distinguish losses ensuing from the adoption of best practices from losses related to other factors. In addition, the DSS is adjusting recommendations based on records, so growers have an incentive to enter timely and accurate information in their records.

While the delivery system of agricultural insurance varies widely among different countries (Smith and Glauber 2012), we restrict our attention to two characteristics: loss-based vs. index-based trigger; and individual vs. collective contract.

Loss-based vs. index-based trigger. Under loss-based insurance, the indemnity is paid when there are actual losses, as assessed by an expert mandated by the insurer. Under index-based insurance, the indemnity is triggered when the realization of an index reaches a defined threshold, rather than based on verifiable losses.⁹ Index-based insurance has the advantages of being less costly for the insurer (who saves on audit costs) and less contestable for the producer (who may resent the expert’s assessment). It has been gaining much interest, first in developing countries where audit costs were prohibitive and more recently in richer countries (Ahmed, McIntosh, and Sarris 2020). Index-based insurance can help reduce moral hazard, adverse selection and administrative costs, but may also create new issues (Jørgensen, Termansen, and Pascual 2020). Its risk-reducing effectiveness depends on how well the actual yield correlates with the index (Glauber 2004). While for climatic insurance, an index correlated with actual losses can be devised using meteorological data, at this date, no adequate index is available for pest attacks on vines. Although hypothetical at this date, a suitable index is the object of much research and might become available in future years. Producers’ interest in such index-based contracts therefore deserves to be evaluated.

⁹We follow the widely-used convention of referring to this type of contract as “index insurance” although it is technically an index security, and is not an insurance in the US Generally Accepted Accounting Principles (Clarke 2016).

Individual vs. collective contract. Most frequently, commercial insurance companies offer individual contracts, sometimes with public support. Alternatively, a mutual fund relies on group contracts, where targeted producers compulsorily adhere to the fund. Mutual funds establish financial reserves, built up through participants' contributions, which can be withdrawn by the members when losses occur, according to predefined rules.¹⁰ The preference for individual vs. group contracts is likely to depend on beliefs and norms that are difficult to capture in the theoretical model and are therefore only assessed in the Discrete Choice Experiment.

2.2 Modelling the impact of pesticide reduction on profits

The producer's financial yield without pesticide reduction is \bar{y} . Reducing treatment intensity reduces the time period during which grapes are protected and thus increases risks of production losses or deterioration of grape quality (if timing is not optimal), at rate $l \in]0, 1]$. Financial yield is reduced to $(1 - l)\bar{y}$ with a probability that decreases in treatment intensity. We assume that the probability of a loss depends on treatments but not the extent of the loss. This reflects the fact that large losses are more frequent under reduced treatments but can also occur under conventional treatments. Each producer's conditions vary with respect to fungal disease. Given these conditions and in the absence of a DSS and of insurance, the producer finds it optimal to choose a fungicide treatment frequency index that we denote TFI . Reducing the TFI below this level increases the probability of losses.

The DSS is set up to achieve a targeted average yield, which corresponds to a probability of losses of ρ^k , detailed below. It is calibrated to maximize environmental benefits by reducing treatments as much as possible without compromising the targeted yield. We assume that following the DSS recommendations allows achieving the lowest possible TFI that is compatible with this targeted yield. We denote this fungicide use level TFI^* .

The percentage of reduction in fungicide use reachable thanks to the DSS is $k \equiv (TFI - TFI^*)/TFI$. Reducing fungicides by $k\%$ reduces the financial costs of applying fungicides,

¹⁰Mutual funds are one of the instruments subsidized by the European Common Agricultural Policy in its risk management toolbox and currently operate in Italy, the Netherlands and France.

denoted C^k , and $C^0 > C^k$, where C^0 is the cost borne when not following recommendations.

The probability of facing losses l when following the DSS, ρ^k , increases in the reduction of treatment intensity k . This is because, for a given TFI^* , producers with higher initial TFI are less experienced with low-fungicide management practices. Producers may overestimate the risks from a lower TFI, compared to the true probability of losses as experts can assess it (for instance thanks to agronomic studies on research plots). The probability ρ^k is therefore a perceived probability.

We assume that the producer is risk-averse and has a concave VN-M utility function $u(\cdot)$. The expected profit of a producer reducing her pesticide use by $k > 0$, thanks to the DSS but in the absence of insurance, would be:

$$\mathbf{E}U_k^{No} = (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l)\bar{y}) - C^k = u(\bar{y}) - \rho^k [u(\bar{y}) - u((1 - l)\bar{y})] - C^k \quad (1)$$

We define the function $L(x) \equiv u(\bar{y}) - u(x\bar{y})$ for all x , as a measure of utility loss. From the properties of $u(\cdot)$, function $L(\cdot)$ is strictly decreasing for $x < 1$ and strictly concave. The more risk-averse the grower, the more concave this loss function. Parameter l measures production losses, while function $L(\cdot)$ measures the corresponding *utility loss* (compared with the best state of nature, which entails a yield of \bar{y}).

Most French vine growers currently do not use a DSS despite its low cost. We therefore assume that the following inequality holds: $\mathbf{E}U_0^{No} > \mathbf{E}U_k^{No} \Leftrightarrow (\rho^k - \rho^0)[u(\bar{y}) - u((1 - l)\bar{y})] > C^0 - C^k$.

This condition can be written as:

$$(NoDSS) : C^0 - C^k < (\rho^k - \rho^0)L(1 - l)$$

The cost savings on fungicides are not enough to compensate for the higher risk of losses when reducing one's TFI, even with the help of the DSS. Although the DSS is an optimization tool, that maintains the probability of loss at ρ^k instead of a higher level in the absence of guidance,

it is not attractive to more risk-averse growers (who face a larger utility loss $L(1 - l)$). This is why additional incentives are needed, such as those provided by conditional green insurance.

2.3 Modelling the subscription to green insurance

We assume that \bar{y} is both the maximum yield (for example set by quality standards of the wine appellation) and the one insured under the contract, at price P . The indemnity I is paid depending on i) whether there are actual losses ($l > 0\%$) in the case of loss-based insurance, or ii) whether the realization of an index reaches a threshold, in the case of index-based insurance. The insurance coverage is α in $[0,1[$ (due to the positive deductible). If the producer follows DSS recommendations and reduces applications to TFI^* , their indemnity is increased by a bonus b funded by public authorities, so their indemnity is equal to $\alpha + b$ % of losses. We assume that $\alpha + b < 1$ so that losses are never fully covered by the contract.

The decision to subscribe or not to the insurance (participation) is taken at the start of the grapevine growing season and the decision to comply with the DSS is made afterwards, during the season. We abstract from timing aspects here, but consider the two decisions, that translate into constraints for the insurance scheme to be effective:

- Participation constraint (*PC*): The producer prefers to take up the insurance if it provides a higher profit than the status-quo strategy (no TFI reduction and no insurance), with expected utility of $\mathbf{E}U_0^{No} = (1 - \rho^0)u(\bar{y}) + \rho^0u((1 - l)\bar{y}) - C^0$
- Incentive constraint (*IC*): The producer prefers to take up the insurance and comply with the DSS if it provides a higher profit than taking up the insurance but not reducing her TFI.

We define the participation and incentive constraints for a risk-averse producer for both types of insurance: loss-based and index-based. Appendix A contains proofs.

Loss-based insurance With loss-based insurance, the indemnity $(\alpha + b)l\bar{y}$ is received in case of yield losses l , as assessed by an expert, which happens with probability ρ^k for a k reduction

in TFI. Under this insurance, a producer complying with the DSS obtains an expected profit of $\mathbf{EU}_k^{LB} \equiv (1 - \rho^k)u(\bar{y}) + \rho^k[u((1 - l)\bar{y} + (\alpha + b)l\bar{y})] - C^k - P$, which can be rewritten as:

$$\mathbf{EU}_k^{LB} = u(\bar{y}) - \rho^k L(1 - l(1 - \alpha - b)) - C^k - P$$

A producer who does not reduce pesticide use and does not subscribe to green insurance faces a probability of loss of ρ^0 and obtains an expected profit of $u(\bar{y}) - \rho^0 L(1 - l) - C^0$.

The producer's participation constraint $(PC)^{LB}$ to the insurance contract is therefore met if the expected profit without insurance \mathbf{EU}_0^{No} (the status quo level) is lower than the expected profit with insurance, that is if:

$$(PC)^{LB} : C^0 - C^k \geq \rho^k L(1 - l(1 - \alpha - b)) - \rho^0 L(1 - l) + P.$$

Participation to the insurance contract is ensured if the cost savings on fungicides compensate for the difference in expected losses (with and without the indemnity) plus the insurance premium. Under reduced treatments, the probability of a loss is higher than under conventional treatments; however, the insurance contract reduces the utility loss due to production losses thanks to the indemnity.

If the producer was to subscribe to the insurance contract without following the DSS, the expected profit (without bonus) would be $(1 - \rho^0)u(\bar{y}) + \rho^0 u(1 - l(1 - \alpha)\bar{y}) - C^0 - P$, that is: $u(\bar{y}) - \rho^0 L(1 - l(1 - \alpha)) - C^0 - P$. An incentive constraint $(IC)^{LB}$ must be satisfied for the insurance contract to induce effective TFI reduction. For insured producers, complying with the DSS is more attractive than not reducing fungicide use if and only if

$$(IC)^{LB} : C^0 - C^k \geq \rho^k L(1 - l(1 - \alpha - b)) - \rho^0 L(1 - l(1 - \alpha)).$$

The green insurance will induce a reduction in TFI if the savings on fungicides are larger than the difference in utility losses given the bonus.

Our modeling allows us to derive a number of implications. Recall that, to fit our context, we assume that the cost savings are not sufficiently attractive in the absence of insurance (condition *NoDSS*). With green insurance, the foregone revenues in case of losses are reduced, and even more with the bonus triggered by compliance with DSS recommendations. The larger the bonus b , the smaller the residual losses borne by the producer, and the more likely it is that the producer prefers to follow the DSS and reduce their TFI. The bonus is therefore an effective complement to the green insurance, as it causes an increase in both participation and compliance with the DSS recommendations.

Constraint $(PC)^{LB}$ implies $(IC)^{LB}$ whenever $P \geq \rho^0[L(1-l) - L(1-l(1-\alpha))]$. When the premium is large enough, compliance is thus never an issue as long as participation is obtained.

If vine growers believe that the DSS cannot much reduce loss frequency (ρ^k is high), they will be both less likely to participate and less likely to comply with the DSS. On the contrary, green insurance is most attractive to the growers who expect ρ^k to be the lowest – because they are more experienced with pesticide-free practices or they face better conditions concerning pest pressure. This result appears paradoxical as it goes contrary to the usual adverse selection in insurance, whereby the actors who bear the highest risk of a loss are the most eager to insure.

The savings on treatments favor both participation and compliance. In this respect, a tax on fungicides, by increasing these cost savings, would be complementary to the insurance bonus. Such a tax would have an impact not only from direct incentives to reduce use, but also by facilitating the adoption of the DSS supported by insurance.

The constraints yield ambiguous results regarding the relative participation of high-use producers vs. low-use ones. For producers who initially had a high TFI, the DSS will likely induce a large reduction k , with the direct negative impacts on participation and compliance noted above. However, for such high-use producers, who tend to face adverse conditions or lack the expertise needed to reduce fungicide use, the initial cost of treatment C^0 will be higher, which tends to make compliance more beneficial.

Index-based insurance The indemnity is triggered by the value of an index, built in order to correlate with the realization of yields, but this correlation is imperfect. Index-based insurance is assumed to be less costly to implement than loss-based insurance, so the premium equals βP , with $\beta \leq 1$.

The distinct events “suffering losses” and “receiving an indemnity” lead to a partition in four states of nature (as in Clarke 2016 and Lichtenberg and Iglesias 2022), whose probabilities are given in Table 1. For instance, with probability ρ_{l+ni}^k , the grapevine grower will suffer losses but no indemnity will be paid. The total probability of a loss is $\rho^k \equiv \rho_{l+i}^k + \rho_{nl+i}^k$ and the total probability of receiving an indemnity is $\rho^i \equiv \rho_{l+i}^k + \rho_{nl+i}^k$. The probabilities with which losses are suffered but no indemnity is paid, and vice-versa, are an essential determinant of the insurance properties of the index-based contract.

Table 1: Probabilities associated to states of nature for index-based insurance

	Losses	No losses	Row total
No indemnity	ρ_{l+ni}^k	ρ_{nl+ni}^k	$1 - \rho^i$
Indemnity triggered by index	ρ_{l+i}^k	ρ_{nl+i}^k	ρ^i
Column total	ρ^k	$1 - \rho^k$	1

Under index-based insurance, the four states of nature need to be distinguished in the expected utility of a risk-averse producer:

$$\begin{aligned}
\mathbf{EU}_k^{IB} &= \rho_{nl+ni}^k u(\bar{y}) + \rho_{nl+i}^k u(\bar{y} + (\alpha + b)l\bar{y}) \\
&\quad + \rho_{l+i}^k u((1-l)\bar{y} + (\alpha + b)l\bar{y}) + \rho_{l+ni}^k u((1-l)\bar{y}) - C^k - \beta P \\
&= \rho_{nl+ni}^k u(\bar{y}) + \rho_{nl+i}^k u((1 + (\alpha + b)l)\bar{y}) \\
&\quad + \rho_{l+i}^k u((1 - (1 - \alpha - b)l)\bar{y}) + \rho_{l+ni}^k u((1-l)\bar{y}) - C^k - \beta P
\end{aligned}$$

The participation constraint is

$$\begin{aligned}
(PC)^{IB} : \quad & (C^0 - C^k) \geq \\
& (1 - \rho^0 - \rho_{nl+ni}^k)u(\bar{y}) + (\rho^0 - \rho_{l+ni}^k)u((1-l)\bar{y}) \\
& - \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right) - \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right) + \beta P
\end{aligned}$$

The incentive constraint is

$$\begin{aligned}
(IC)^{IB} : \quad & (C^0 - C^k) \geq \\
& [\rho_{nl+i}^0 u\left((1 + \alpha l)\bar{y}\right) - \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right)] \\
& + [\rho_{l+i}^0 u\left((1 - (1 - \alpha)l)\bar{y}\right) - \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right)] \\
& + (\rho_{nl+ni}^0 - \rho_{nl+ni}^k) u(\bar{y}) + (\rho_{l+ni}^0 - \rho_{l+ni}^k) u\left((1 - l)\bar{y}\right)
\end{aligned}$$

Comparative statics are similar to loss-based insurance, but low DSS performance in terms of reducing the frequency of losses (high ρ^k) makes both participation and compliance less attractive. As for loss-based contracts, a higher premium βP increases the probability that the participation constraint is stringent enough to imply compliance with DSS recommendations (i.e. the incentive constraint is also fulfilled).

The index increases the variability in the producer's return: it creates a very positive state where indemnity is received in the absence of losses and a very negative state in which no indemnity is received despite losses. Despite this increase in variability, index-based insurance can still be attractive if the discount on the premium $(1 - \beta)$ is large or if the probability of receiving an indemnity while not suffering losses (ρ_{nl+i}), is large. Interestingly, if producers overestimate the probability of losses ρ^k , they will expect to bear actual losses more often than the probability with which the index leads to indemnification (ρ^i), and will be more reluctant to insure, despite facing a higher perceived risk. Similarly, growers further away from TFI^* will be less likely than the other growers who depend on the same index (same ρ^i) to prefer index-based

insurance since they face a higher probability of actual losses ρ^k .

Knowing the producer's risk aversion is not sufficient to determine whether she will be attracted by the index-based contract, since this attractiveness depends on both the curvature of the utility function and the beliefs about the probabilities of the four states. The more pessimistic the producer is about ρ^i , the less attractive the index-based insurance, as the variance effect will tend to dominate.

Public support to green insurance Two types of public support can be considered: financing the bonus (increase in b) or the premium (reduction in P).¹¹ The model shows that both will favor insurance subscriptions (both for index and loss-based contracts). However, a subsidized premium has no impact on the incentive constraint under index-based contracts. Only the subsidized bonus favors compliance with the DSS under both loss- and index-based contracts.

For the bonus to indeed induce compliance, the insurer needs to check the recorded treatments to verify this compliance. This check is required even though there is no assessment of real losses under an index-based contract. Checking treatment record files does not entail the same costly expertise procedure as going into the field to assess the extent of real losses. It can be done under index insurance without jeopardizing its financial advantage over loss-based contracts.

2.4 The need for an empirical test

The model allows us to explore how the decision to subscribe to green insurance is impacted by the probability and value of losses ($\rho^k l \bar{y}$), the increase in risk due to pesticide use reduction ($\rho^k - \rho^0$), as well as by the cost savings from pesticide use reduction ($C^0 - C^k$) and financial characteristics of the insurance contract. Three conclusions from the model are particularly relevant to test empirically. First, the growers who expect to be able to reduce treatments with less

¹¹Subsidization of the insurance premium is the choice made in France for multi-peril crop insurance. In reality, these choices are not entirely symmetrical for the regulator, since an intervention lowering the premium implies a (moderate) expense for each contract policy taken out, whereas an intervention increasing the compensation rate implies a (potentially higher) expense, but only in the event of a default of the DSS.

frequent losses (ρ^k closer to ρ^0) are the ones who are most likely to subscribe a loss-based insurance contract. Second, when the insurance premium (P or βP) is sufficiently high, participation implies compliance, i.e. insurance adoption will lead to a reduction in fungicide use thanks to DSS recommendations. Last, an increase in risk with index-based insurance makes it less attractive, despite its lower price. The model focuses on one major source of heterogeneity across producers: the initial fungicide treatment frequency index (TFI). It impacts the probability of losses when less fungicide is used (ρ^k) due to differences in production contexts and/or expertise in crop protection. Other producers' characteristics such as risk-aversion, beliefs, or attitudes towards digital farming may also impact the decision to subscribe to the green insurance scheme under study. To account for this larger set of factors, we assessed the impact of insurance and producers' characteristics on subscription decisions through a choice experiment. The design is detailed in the next section.

3 Method

To analyze preferences for a green insurance which is not available at the time of the study, we rely on a Discrete Choice Experiment (DCE). DCEs are particularly valuable for investigating individuals' preferences in hypothetical decision-making situations, when purchase or adoption data are not available (Louviere, Hensher, and Swait 2000). The method has been previously used to evaluate *ex-ante* programs targeting pesticide use reduction. For example, in grapevine production, Kufhuss et al.(2016) and Lapierre et al.(2023) rely on DCE to analyze the attractiveness of innovations in AES design, to better account for uncertainty on the costs and benefits associated with the adoption of new practices for herbicide reduction. The method has also been used to analyze preferences for insurance schemes conditional on compliance with specific farm practices. Jorgensen et al.(2020) study the willingness to pay (WTP) of Danish crop producers for an insurance contingent on investing in sustainable soil management; and Heikkilä et al.(2016), that of Finnish producers for animal-disease insurance, conditional on fulfilling bio-security requirements to reduce sanitary risks. Both include the contract price

as monetary attribute and estimate the impact of best management practice requirements on WTP. Jorgensen et al.(2020) also estimate the impact of the insurance type (yield vs rainfall), while Heikkilä et al.(2016) include an attribute on the insurance provider (private insurer vs mutual fund). In the next sections, we present our experimental design, data collection process and methods for data analysis.

3.1 Choice experiment design

Four attributes presented in Table 2 characterize the different types of green insurance systems tested in the choice experiment: individual or group contracts, loss-based or index-based damage evaluation, level of coverage and premium. The first two correspond to binary qualitative dimensions and the other two to financial attributes, with four levels for each. Attributes and levels have been chosen to be relevant and realistic, taking into account literature and experience of pioneering contracts in the South West of France (VitiREV), cf. Raynal, Davadan, et al. 2022 for agronomic details. We have then verified the experimental design with experts, including insurers, vine growers, and agronomic advisers. Finally, the attributes have been tested in two pilots in November 2022 and May 2023, with respectively 24 and 43 producers. The design has been pre-registered.¹²

The financial parameters of the contract are twofold: First, subscription to the insurance contract requires paying a premium, between 3% and 8% of the insured capital. This insured capital is equal to the insured yield multiplied by the price at which the vine grower values their production and by total surface. Note that, to reduce moral hazard, grapevine growers have to insure their entire vineyard. The insurance premium is presented both in %, and in €/ha according to the insured yield and production value provided by the respondent in questions preceding the choice cards. Second, the coverage level defines the guaranteed fraction of the losses (between 40% and 65%). There is a positive deductible but, to simplify, no supplementary triggering threshold is applied.

¹²<https://osf.io/mbvpa>

Grapevine growers following DSS recommendations receive an additional 30% compensation, financed by public authorities.¹³ This amount was determined with policymakers and insurers and we decided not to vary it in order to reduce design complexity and to be able to analyze the impact of the total coverage (including the bonus) on the willingness to subscribe to insurance. Producers can choose to stop following DSS recommendations during the year if they turn out to be incompatible with their farm objectives and aversion to risk, which is an interesting flexibility for growers and possibly a factor of attractiveness. We also do not vary the level of best practice requirements, contrarily to Jorgensen et al.(2020) and Heikkilä et al.(2016), since partial adoption of DSS recommendations is unlikely to reach the environmentally optimal TFI and will lead to more subjective and complex control by insurers.






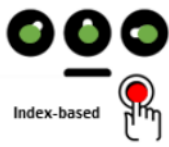
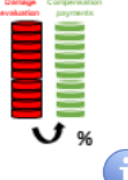

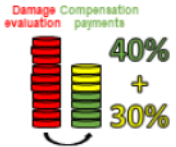



Behavioral interventions can be effective in increasing the adoption rate of programs aimed at influencing producer practices (Ferraro et al. 2022; Serfilippi, Carter, and Guirkingner 2020). In particular, we know that equivalent descriptions of outcomes using different framing can result in different choices (Tversky and Kahneman 1981). There is mixed empirical evidence on the effectiveness of positively-framed versus negatively-framed information in influencing pro-environmental choices (Lopes, Tasneem, and Viriyavipart 2023). We contribute to this field of research, by assessing whether a different framing of the bonus incentive has an impact. To do so, we rely on a split sample approach, comparing a bonus and penalty framing (Tonsor 2018). In the bonus framing, the insurance coverage rate is presented as a base indemnity plus a 30% bonus in case of full compliance with DSS recommendations. In the penalty framing, the coverage is presented as the full indemnity minus a 30% penalty in case of non-compliance with DSS recommendations. From the behavioral literature, we know that the penalty framing is likely to

¹³The system relies on the ability to observe whether growers have followed the DSS recommendations. Monitoring treatments has been a long-established practice in vine growing and has become more professional over the years. Today, registers have evolved from simple treatment books used solely by the winegrower to observe and compare their performance year after year, to (digital) notebooks which, while remaining private, are controlled by the authorities (especially due to health regulations to prevent excess exposure of employees to potentially toxic products). So it is very likely that participants had in mind accurate registration of treatments when answering the DCE. Moreover, the DSS itself provides incentives for correctly recording treatments: Entries in the DSS are necessary for updating the recommended level of protection. It is therefore in the winegrower's interest to accurately report the treatments carried out.

reduce willingness to participate in the scheme (due to loss aversion since non-compliance with DSS recommendations reduces compensation). On the other hand, loss aversion can reinforce the incentive to comply with DSS recommendations. As a result, we expect vine growers to be more willing to pay for green insurance in the bonus framing, but less likely to comply with DSS recommendations, compared to the penalty framing.

We created a Bayesian D-efficient design using NGENE based on prior results from the pilot survey. To make the presented alternatives as realistic as possible, restrictions were included in the design: we rejected choice cards where index insurance is more expensive than loss-based insurance unless it provides better coverage. This resulted in a design with 12 choice cards, divided into 3 blocks of 4 cards. Moreover, we control for order effects due to learning and lassitude by having 3 other blocks with the same choice cards, but presented in a different order. To measure framing effects, the 3x2 blocks are duplicated (6 with the penalty version of the indemnity attribute, and 6 with the bonus version). Thus, subjects were randomly assigned to one of the 12 blocks. Figure 1 shows an example of a choice card, with two insurance contracts labeled “A” and “B” and an opt-out option.

Figure 1: Example of choice card

	A	B
TYPE OF CONTRACT 	Collective 	Individual 
DAMAGE EVALUATION 	 Loss-based	 Index-based
COVERAGE 		
PRICE 	 8 % of insured capital	 5 % of insured capital
For your vineyard	(Average yield* Value* 0.08) €/ha	(Average yield* Value * 0.05) €/ha

	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table 2: Attributes and levels

Attributes	Levels						
Type of contract	<p>Individual: Each vine grower decides individually whether or not to subscribe to the insurance (as for a classic insurance).</p> <p>Collective: The vine growers subscribe to a group contract, for example within the framework of a mutual fund between vine growers of the same cooperative, appellation or wine basin. In this case, membership is compulsory for all the vine growers in the group concerned.</p>						
Damage evaluation	<p>Loss-based: Real losses are assessed by an expert, who comes to observe in each grower's plots the consequences of fungal diseases and then the harvest. The amount of the compensation depends on the expert's evaluation of real losses. The expertise allows an evaluation of the losses specific to each grower farm, but is subject to the subjectivity of the expert and is more expensive than index evaluation.</p> <p>Index-based: Losses are estimated based on a local fungal pressure index measured, for example, in control vineyards near each grower's home. The amount of compensation depends on the value of this index. Real losses will be sometimes higher and sometimes lower than in the control vineyards, but the index can help to reduce insurance costs and make the assessment of losses more objective than expert evaluation.</p>						
Coverage	<table border="0"> <thead> <tr> <th>Bonus framing</th> <th>Penalty framing</th> </tr> </thead> <tbody> <tr> <td>Base indemnity + Bonus 40+30%,50+30%,55+30%,65+30%</td> <td>Total indemnity - Penalty 70-30%,80-30%,85-30%,95-30%</td> </tr> <tr> <td>The coverage is a percentage of assessed losses. No triggering threshold is applied. The coverage is higher for growers respecting the treatment protocol (dates, doses) and not carrying out any treatment other than those recommended by this protocol, thanks to a bonus financed by public authorities.</td> <td>The coverage is a percentage of assessed losses. No triggering threshold is applied. A part of this coverage is funded by public authorities. A penalty of 30% (the part funded by public authorities) will lower the total coverage for growers preferring not to follow the treatment protocol (dates, doses) and carrying out other treatments than those recommended by this protocol.</td> </tr> </tbody> </table> <p><i>Coverage levels have been chosen such that they correspond to values growers are used to: The 70% level corresponds to 30% deductible imposed by the EU to subsidize insurance schemes (at the time of the experiment). The 80% level corresponds to the base contract for climatic risks in the new French law on climatic insurance (20% deductible). The 95% level for total coverage corresponds to the contract currently under test in two cooperatives in the Southwest of France (VitiREV project); This pilot entails very advantageous conditions as it is highly subsidized (5% deductible). We added an intermediary level of 85%.</i></p>	Bonus framing	Penalty framing	Base indemnity + Bonus 40+30%,50+30%,55+30%,65+30%	Total indemnity - Penalty 70-30%,80-30%,85-30%,95-30%	The coverage is a percentage of assessed losses. No triggering threshold is applied. The coverage is higher for growers respecting the treatment protocol (dates, doses) and not carrying out any treatment other than those recommended by this protocol, thanks to a bonus financed by public authorities.	The coverage is a percentage of assessed losses. No triggering threshold is applied. A part of this coverage is funded by public authorities. A penalty of 30% (the part funded by public authorities) will lower the total coverage for growers preferring not to follow the treatment protocol (dates, doses) and carrying out other treatments than those recommended by this protocol.
Bonus framing	Penalty framing						
Base indemnity + Bonus 40+30%,50+30%,55+30%,65+30%	Total indemnity - Penalty 70-30%,80-30%,85-30%,95-30%						
The coverage is a percentage of assessed losses. No triggering threshold is applied. The coverage is higher for growers respecting the treatment protocol (dates, doses) and not carrying out any treatment other than those recommended by this protocol, thanks to a bonus financed by public authorities.	The coverage is a percentage of assessed losses. No triggering threshold is applied. A part of this coverage is funded by public authorities. A penalty of 30% (the part funded by public authorities) will lower the total coverage for growers preferring not to follow the treatment protocol (dates, doses) and carrying out other treatments than those recommended by this protocol.						
Premium	<p>3%, 5%, 6%, 8% of insured capital</p> <p>Subscribing to insurance is costly and the price is defined in % of insured capital. Insured capital equals insured yield multiplied by the price value of production.</p> <p><i>Price levels have been chosen such that the expected net gain from insurance is positive for producers in an average situation for France (average yield of 50 hl/ha with a value of €100/hl (€5000/ha of insured capital), and expected losses of 10% per year). In most of these scenarios, insurers can also make money if the 30% coverage bonus is subsidized by public authorities.</i></p>						

3.2 Data collection

In autumn and winter 2022, we first collected forecasts from experts on vine growers' preferences for the different attributes, and on impacts of producers' characteristics on these preferences (Appendix B). They helped us elaborate hypotheses to be tested (Appendix C).

The survey was administered online to around 20,000 vine growers (on some 59,000 vine-growing farms in France), via a company selling inputs and material for vineyards and several other channels (the list of all these channels is available in Appendix G). The growers received no financial incentive to participate, but were told that their answers were important to design future pesticide policies. We received 412 complete answers (participation rate of approximately 2%).

The survey was structured as follows: The questionnaire started with a filter question to ensure that only vine growers taking financial and vineyard sanitary decisions were participating. Then, producers were asked to provide general data about their vineyard characteristics and crop protection strategy. Third, the green insurance scheme was presented. In the fourth part, the DCE was conducted with 4 choice cards, followed by questions to understand choice heuristics. The English version of the questionnaire is available in Appendix H.

3.3 Data analysis

Based on DCE results and field data on DSS environmental performance, we provide estimates on insurance adoption rate according to contract features, impact on fungicide use and efficiency of public support to the insurance scheme.

3.3.1 Adoption rate

The econometric estimation is in line with the behavioral framework of the random expected profit approach developed by McFadden (1974). Grapevine growers are assumed to choose their preferred insurance scheme such that the net expected profit from that contract is greater than either the other contract or opting out. For each vine grower i the expected profit obtained from

alternative s in choice set t can be written as:

$$U_{ist} = V_{ist} + \epsilon_{ist} = X'_{ist}\beta_i + \epsilon_{ist}$$

The expected profit is a function of observable attributes V_{ist} plus an unobserved random component ϵ_{ist} (the stochastic error term). X_{ist} refers to the vector of levels of the attributes, i.e. the insurance scheme characteristics. We also include in X_{ist} an Alternative Specific Constant (ASC) equal to one for the status quo alternative of not entering into any of the proposed contracts. The price and coverage for each alternative are specified as a continuous variable. For the other attributes, we include one dummy variable for each level of the attribute described in Table 2 except one. This excluded level per attribute represents the reference level for each attribute.

To estimate preferences, we rely on the Random Parameter Logit (RPL) model which allows parameters to vary randomly across respondents such that it gives a continuous distribution of preferences (Boxall and Adamowicz 2002). We assume all respondents prefer contracts with a lower premium, and therefore consider log-normal distributions of individual price coefficients. All other coefficients are assumed to be normally distributed. To further understand heterogeneity, we also estimate a latent class model. Latent class models work similarly to mixed logit models, except that the distribution of β coefficients is assumed to follow a discrete rather than normal mixing distribution (Pacífico and Yoo 2013).

From RPL estimates, we obtain individual parameters for each attribute, and can calculate the utility of each respondent for different insurance types. In our analysis we focus on the three insurance schemes the most likely to be offered on the market. Scheme 1 (S1) is an individual and loss-based insurance: this disease insurance could be offered with similar features as the current multiple-peril crop insurance available to vine growers in France. Scheme 2 (S2) is an individual index-based insurance. Scheme 3 (S3) is a group index-based insurance.¹⁴

¹⁴One example of such contract S3 is described by Harris and Swinton (2012): producers receive indemnities based on the annual deviation from long-run production averages among a cohort of nearby producers. This approach aims to lower monitoring costs by using county-wide information to inform claims. It also reduces moral

We assume that a grower subscribes to insurance if their utility from a given insurance scheme S defined by its X characteristics x_S is higher than their utility from the status-quo (as captured by the coefficient associated to the alternative specific constant ASC). For each respondent, we know whether they would subscribe or not to the insurance for different prices ranging from 3% to 8% (while we keep a fixed 50% coverage), and we can calculate an adoption rate at sample level.

3.3.2 Impact on fungicide use

To estimate the potential impact of green insurance on fungicide use in French vineyards, we rely on the pesticide use reduction (k) that could be obtained thanks to the DSS recommendations for those willing to subscribe to insurance for the preferred contract. We therefore proceed in three steps: (1) identification of the preferred contract; (2) identification of those willing to subscribe to such contract; (3) computation of the pesticide reduction potential of those adopters.

When moving from (2) to (3), we assume that all vine growers subscribing to insurance will fully comply with DSS recommendations. This is in line with responses to a question on compliance that we asked at the end of the survey, and also with our theoretical results which indicate that participation will likely imply compliance, given high enough premia (i.e. the incentive constraint is satisfied).¹⁵

The DSS leads to different amplitudes of reduction depending on the initial situation of the

hazard since losses evaluation cannot be manipulated by a single producer (Baerenklau 2005). If appropriately designed, these contracts can also incentivize change in aggregate behavior by motivating producers to improve production practices relative to neighbors.

¹⁵After the choice experiment, we asked growers whether they would most likely follow the recommendations to be sure to benefit from the bonus, or would rather focus on the base indemnity and not reduce their pesticide use (an intermediary choice was also offered: "Follow the recommendations at the beginning of the season and stop if they do not suit you". Those who have selected this intermediary option are also considered as following DSS recommendations). We can distinguish "adopters" of green insurance and "full adopters": adopters are those with a utility from an insurance contract higher than their utility from the status-quo, so that their participation constraint (PC) is satisfied; full adopters are willing to follow DSS recommendations so that their compliance incentive constraint (IC) is also satisfied. In the pre-registration, we indicated that we would measure the impact in terms of TFI reduction potential only for the full adopters. However, only 231 out of the 412 respondents answered the question on DSS adoption. And only 10% indicated they would not follow DSS recommendations and therefore only count on the base indemnity. We therefore decided to assume that those willing to subscribe to green insurance would also most likely follow DSS recommendations. Estimates of average TFI reduction are robust to dropping respondents who declared they won't follow DSS recommendations.

winegrowers (e.g., low or high pest pressure and pesticide use, conventional or organic farm practices). Assuming a fixed TFI reduction in % to assess DSS performance would therefore be misleading. Rather, to estimate the potential impact of the uptake of the DSS on pesticide use, we rely on two external sources of information: (i) field trial data on TFIs obtained via the implementation of the DSS on two different vineyards as part of the VitiREV program (one run in conventional mode and the other in organic mode) (Raynal, Davadan, et al. 2022; Raynal, Debord, et al. 2024) ; (ii) distributions of actual TFIs by region and farm practices (conventional vs organic) obtained from a survey on agricultural practices collected by the French ministry of agriculture in 6,000 vineyard plots in France. Coupling these two data sources over a common year (2019) to control for inter-annual variation, we obtain an empirical measure of TFI^* , the lowest achievable treatment level for the targeted yield. We find that conventional producers having followed the DSS recommendations in the VitiREV trials are positioned in the 2nd percentile of conventional plots in Nouvelle Aquitaine with lowest TFI in 2019. The organic fields in the trial were in the 35th percentile of organic plots in Nouvelle Aquitaine ($Q_{conventional} = 2$; $Q_{organic} = 35$). In other words, those field experiment results show that benefits in terms of pesticide reduction are lower for organic producers. This may be caused by the fact that the DSS considered here was initially developed for conventional practices, which would call for specific development of DSS well suited for organic practices. It may also be that organic producers are already more efficient in reducing unnecessary applications by adapting agronomic practices.

Following the assumptions on TFI^* , for each respondent, we can calculate the TFI reduction potential k in % from their current TFI (average over the last 3 years).¹⁶ As a first approximation, we assume that the same performances can be obtained in other regions. 2019 being the only year common to both sources, it is the reference year on which we base our analysis.

¹⁶In the choice experiment, to facilitate respondents' understanding, and as supported by the IFV Technical Institute, we communicated that following DSS recommendations allows reducing fungicide use by 40 to 70%, depending on the year and fungal pressure. With our sample, we verify *ex-post* that the reduction potential calculated as explained above is between 0 and 90 %, with an average and median of 31%. This is in line with a meta-analysis conducted by Lazaro et al. (2021) that shows that DSS can reduce fungicide treatments by at least 50% without compromising disease control.

Of course, these data from a single year of experimentation must be treated with caution since TFIs vary from one year to the other.

To adjust for sampling bias and extrapolate our results to the population of French vine growers, we simulate the insurance uptake and impact at the national scale by approximately correcting for the sampling bias (over-representation of organic farmers). We define eight cells characterized by three variables: whether the farm follows organic practices or not, whether it is located in a high or low fungicide use region, and whether the farm has a high or low TFI compared with the other producers in the same region with the same type of practices. To calculate the weights, we allocate the 57,878 French vine growers to the 8 cells (Table 3). The 22 French wine regions are ranked according to the average fungicide TFI in the region. We name “high-use regions” the eleven regions with the highest average TFI. The number of organic producers in each region is obtained from a national database covering organic producers (Agence Bio 2020). This number is then divided into two groups: high-users are those with a higher average TFI than the region median in the last 3 years for the same type of practices.

Table 3: Share of producers in each cell, used as weights to adjust for sampling bias and extrapolate results at population level (n=57878)

Non-organic (n=48034)	High users	Low users
High-use regions	23.6%	23.6%
Low-use regions	17.9%	17.9%
Organic (n=9844)	High users	Low users
High-use regions	2.8%	2.8%
Low-use regions	5.7%	5.7%

Source: Agence Bio (2020) for number of organic producers and French agricultural practices survey 2019 (French agricultural ministry 2022) for average TFI by region.

We then extrapolate the cell-specific adoption rate and average impact of green insurance on fungicide use to the population, accounting for the weight of each cell. Finally, we conduct a range of sensitivity analyses on the underlying assumptions on the efficiency of the decision support system to reduce producers’ pesticide use.

3.3.3 Cost-efficiency

We investigate whether public authorities would find it beneficial to finance the green insurance bonus, rather than other programs targeting pesticide use reduction. The cost-efficiency ratio CE is measured as the public cost in euro to reduce TFI by 1% :

$$CE = \sum_{i=1}^n \frac{b\rho_k l \bar{y}_i}{k_i}$$

where k_i is the pesticide use reduction of grower i and \bar{y}_i their insured capital. The cost for public authorities is the bonus b equal to 30% of the expected losses, which are assumed to equal 10% of insured capital annually ($\rho_k l = 0.1$), in line with DSS predictions. We assume that the incentive constraint is satisfied for all growers, who are thus all eligible for the bonus.

4 Results

We test our pre-registered hypotheses (listed in Appendix C), and run complementary exploratory analyses. We first investigate the profile of vine growers more likely to adopt the green insurance. We then analyze contract features more likely to trigger adoption. In particular, we compare preferences for individual vs group contracts, loss-based vs index-based insurance, and a bonus vs penalty framing. We also provide estimates of the reduction in fungicide use likely to be obtained with green insurance, given the field trial data, and the resulting cost-efficiency of the instrument.

4.1 Descriptive statistics

The final sample included in the analysis consisted of 412 responses. The sample is compared to the population of 57,878 producers growing vine for socio-demographic and farm characteristics in Table 4. 75.24% of respondents are farm owners. The average farm size in the sample is twice as large as the French viticulture average (many owners of small vine areas use service providers for technical management of the vineyards, and therefore do not correspond to the

profile sought in our survey), but heterogeneity is very high, both in the population and the sample (including an outlier of 6,000 ha). 42.2% are members of cooperatives. 26.9% of vine growers are certified organic farming (17% in the population), 6.1% transitioning to organic certification and 51.7% have obtained an alternative certification such as High Environmental Value or Terra Vitis, two environmental certifications, dissociated from but compatible with organic certification, and giving access similarly to an official label on the marketed products. These numbers suggest that the sample is more experienced with fungicide reduction than the population.

Average survey completion time was about 22 minutes. We checked reading time of attributes and interview time to be sure to avoid questionnaire-surfing in our responses.

Table 4: Sample characteristics

Variable	Description	Sample mean	Population
Vine grower's characteristics			
Age	Years old	49.46	46.50
Gender	1 = male, 0 = female	0.876	0.781
Seniority	Years of work in vines	23.3	
Education in viticulture	1 = Yes, 0 = No	0.767	0.92
Vineyard's characteristics			
Land size (vineyard)	Hectares	45.8	22.1
Ownership of the vineyard	1= Yes, 0 = No	0.752	
Protected indication (see Note 1)			
Protected denomination of origin (AOP/AOC)	1 = Yes, 0 = No	0.90	0.46
Protected geographic indication (IGP)	1 = Yes, 0 = No	0.37	0.28
Other	1 = Yes, 0 = No	0.20	0.08
Collective implication			
Member of a cooperative	1 = Yes, 0 = No	0.422	0.58
Collective score (see Note 2)	between 1 and 5	1.11	
Certification (see Note 3)			
Organic farming	1 = Yes, 0 = No	0.269	0.17
In conversion towards organic farming	1 = Yes, 0 = No	0.061	
Other (High Environmental Value, Terra Vitis)	1 = Yes, 0 = No	0.517	0.3
None of these certifications	1 = Yes, 0 = No	0.153	

Note 1: Respondents can sell their production under several categories. The total therefore sums to more than 100%. The population statistics represent the share of total production under each indication, which cannot be directly compared to the share of respondents selling partly under each category.

Note 2: The collective score, between 1 and 5, is the sum of the grower's participation (yes=1; no=0) to a wine cooperative, a cooperative to share material (CUMA), a collective sale point, a group to share best environmental practices (GIEE) and institutions as representative of the vine producers.

Note 3: When a farmer has both the organic certification and another one, we identify it as organic. The total therefore sums to 100%.

4.2 Adopters' profile

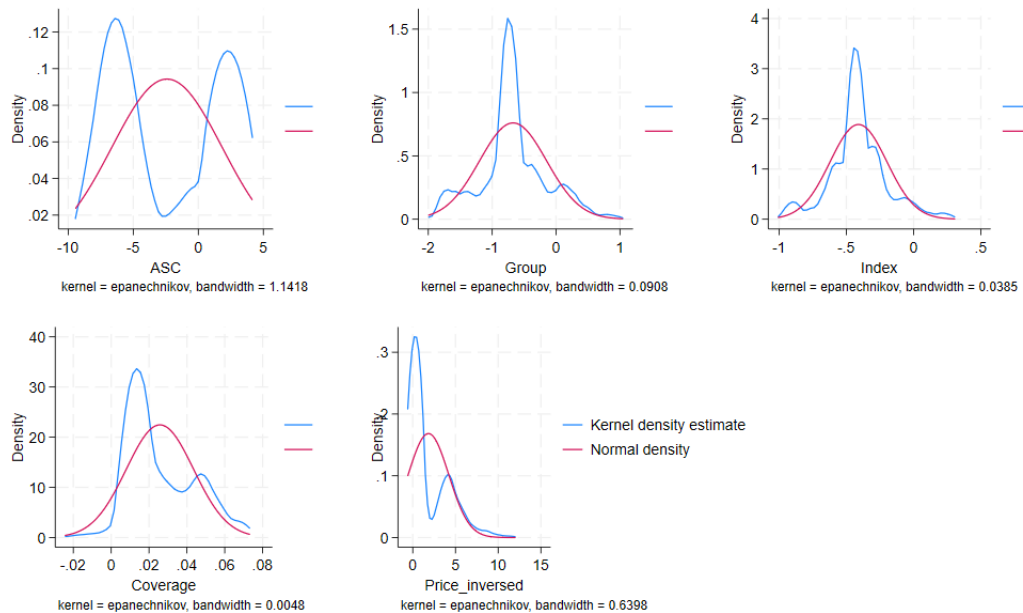
While we have a split-sample approach to compare the bonus and penalty framing, our analysis is performed on the full sample. Indeed, we found that framing has no significant effect on the number of insurance subscribers, nor on the TFI profile of the subscribers. Producers are not significantly less likely to opt out in the bonus framing (the coefficient $ASC \times Bonus$ is not significant, cf. Figure 3). Separate estimations for the bonus and penalty framing sub-samples confirm this result (Appendix D). Moreover, the framing has no selection impact: producers subscribing to insurance in the bonus framing group are not significantly different from those in the penalty framing group in terms of TFI reduction potentials (Figure A.1 in Appendix D). All the remaining analysis is therefore run on the full sample.

With the RPL model, we find that vine growers overall prefer the green insurance to the status-quo (the coefficient associated to the alternative-specific constant is negative), suggesting a significant interest for the scheme (Figure 3).

Two classes of adopters. Figure 2 displays interesting results regarding the distribution of the individual coefficients in the RPL model. The distribution of individual coefficients for the ASC and, to a lower extent, price and coverage is bimodal. This suggests that a share of our sample is more interested by green insurance (negative coefficient for the alternative-specific constant ASC) and another share is more sensitive to the financial parameters (with high coefficients for the price and coverage attributes). Latent class estimates in Table 5 confirm that our sample can be divided into two classes. The number of classes has been chosen to ensure interpretability, together with maximizing class membership prediction accuracy (Table A.5 in Appendix F). Class 1 comprises of about 59.5% of the respondents. For class 1, the coefficient estimates are close to those estimated by the RPL model. Given the negative sign associated with ASC, growers belonging to class 1 are on average interested by the green insurance. Moreover, they have a lower price elasticity than class-2 respondents. On the contrary, respondents in class 2 are not significantly more interested by the insurance than the status-quo, and have

no significant preference for the specific insurance attributes. However, they have a high-price elasticity.

Figure 2: Random Parameter Logit: Individual coefficients. Kernel density estimates



Determinants of class membership In order to test the two hypotheses on the influence of the current pest management strategy and the risk profile of the producer on insurance subscription, we study their impact as potential determinants of class 1 membership.

Concerning the pest management strategy, we find that transitioning towards organic certification has the strongest influence on the probability of belonging to class 1. Organic and other certifications also increase the probability of belonging to class 1 compared to having no certification, but to a lower extent. This is consistent with the results from our theoretical model, whereby growers who expect a lower probability of losses (ρ^k) under greener practices should be more attracted to the insurance contract. We can indeed expect that growers who have taken the decision to transition to organic farmers have more optimistic beliefs about their ability to manage vines under reduced treatments, due to prior experiences in this field. Stated

willingness to reduce fungicide use in the near future (variable *sanitary strategy*) also increases the probability of belonging to class 1 (possibly for the same reason).

Concerning the influence of the risk profile on willingness to subscribe to green insurance, we test the impact of the following variables: self-evaluated risk tolerance, being insured against climatic risk, having diversified crops or having larger vineyards. None has an influence on the probability of belonging to class 1.

In Appendix E (Table A.6), we present estimates on adoption rates by French region, to highlight heterogeneity.

Table 5: Latent class: Probability to subscribe to green insurance

	Class 1 (60%)	Class 2 (40%)
ASC	-1.587*** (-5.64)	0.631 (0.62)
Group	-0.430*** (-5.69)	-0.151 (-0.34)
Index	-0.294*** (-4.17)	-0.430 (-1.03)
Coverage	0.0192*** (3.79)	0.00203 (0.10)
Price	-0.0982*** (-3.96)	-0.535*** (-3.83)
Probability to belong to class 1		
Organic	0.929** (2.74)	
Organic_transition	2.293*** (3.38)	
Other certification	0.911** (2.95)	
Sanitary strategy	0.348** (2.77)	
Constant	-1.354** (-3.03)	
N	4944	

t statistics in parentheses

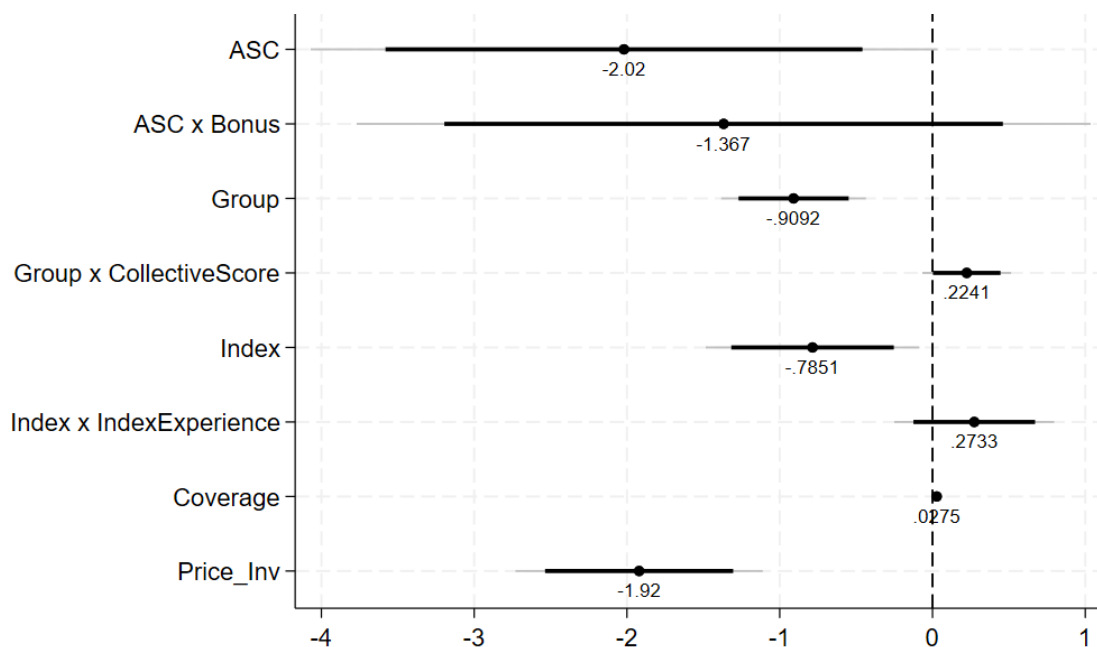
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

4.3 Preferences for contract features

Better coverage increases the probability that the vine grower will adopt the insurance scheme and higher contract price decreases this probability (Figure 3), confirming one of our pre-registered hypotheses. While both characteristics have a significant impact, their effect sizes are very different: the contract price has a much bigger effect than the percentage of the base coverage.

With regard to the contract design features, we find that on average, producers prefer individual contracts to group contracts. We also find a preference for loss-based compared to index-based insurance, but the absolute value of this coefficient is low.

Figure 3: RPL model: Impact of attributes on the probability to subscribe to green insurance



Note: The choice of contracting to green insurance is explained by contract attributes (Bonus, Group, Index, Coverage, and log-normal Price) and some interaction variables -selected according to pre-registered hypotheses.

We focus on two sources of heterogeneity with regard to preferences for the Group and Index attributes. We find that the growers engaged in groups of producers (such as cooperatives where wine-making or vineyard materials are mutualized, or collective sale points) are less reluctant to

adopt group contracts (variable `CollectiveScore`). However, we find no evidence that knowledge or prior experience with index insurance has an influence on preferences for the index-based contract (variable `IndexExperience`).

We also calculate the adoption rate for different types of green insurance contracts (S1, S2, and S3 defined in section 3.3.1) (Table 6). In the sample, between 45% and 58% of the vine growers are likely to subscribe to green insurance depending on contract design and prices. Adjusting for sampling bias, based on adoption rates such as the one presented in Table 3 for contract S1, the adoption rates vary between 48% and 60%.

As expected from previous results on preferences for individual and loss-based attributes, the adoption rate is higher for scheme S1. Since differences in adoption rates across contract types and prices are limited, in the remaining analysis we focus on one contract: the preferred contract (S1), in the case of fair insurance (5% price and 50% coverage). This contract is considered fair since the loading factor is equal to one when one assumes an expected annual loss of 10%, as expected under production with the here selected DSS.¹⁷

Table 6: Adoption rate by contract type and price (for 50% coverage)

Contract type	S1	S2	S3
Price	Individual loss-based	Individual index-based	Group index-based
3%	58 (60)	56 (58)	53 (54)
5%	54 (56)	51 (54)	48 (51)
6%	51 (54)	49 (53)	47 (50)
8%	49 (51)	48 (51)	45 (48)

Note: The first number in each cell corresponds to the percentage of adopters in the sample.

The number in parenthesis corresponds to the percentage extrapolated at population level, after correcting for sampling bias.

4.4 Impact on fungicide use

To estimate the potential impact of green insurance on fungicide use in French vineyards, we rely on the pesticide use reduction (k) that could be obtained thanks to the DSS recommendations

¹⁷In practice, there may be only a limited number of agricultural insurers willing to offer a green insurance, so that perfect competition may not apply. However public authorities may be able to impose actuarial fairness as a requirement associated with the public bonus. Insurers may find this attractive if they expect their customers to subscribe to other products they may offer.

for those willing to subscribe to the preferred contract (S1) at the 5% price and 50% coverage.

Overall, following the method described in 3.3.2, we estimate that adopters in the sample would reduce their fungicide treatment by 35% on average and a quarter of them can reduce their fungicide treatments by more than 55%. But the average TFI reduction potential hides important heterogeneity: the expected TFI reduction potential of those willing to subscribe to green insurance ranges from 0 to 84.9%. We highlight in Table 7 the differences across practices (organic or not), regions and users' relative position in the region with regard to their TFI. The highest impact is expected for non-organic producers treating more than the median TFI in low-use regions (-74.70% compared to their initial TFI on average). The impact is higher in low-use regions since other growers in these areas have managed to reduce their TFI, which indicates favorable environmental conditions and lower pest pressure. Extrapolating results to the population, given that 56% of the population would adopt S1-type green insurance, and assuming DSS performances measured in Nouvelle Aquitaine in 2019 for other regions and years, fungicide use could be reduced by 45% on average at the national level (compared to 35% in our sample due to the over-representation of organic producers, who have on average a lower reduction potential).

Table 7: Potential TFI reduction in % for green insurance adopters, by individual intensity of use, intensity of use of the region and farm practices (organic or non-organic)

Non-organic	High users	Low users
High-use regions	56.63 (23.6%)	27.65 (23.6%)
Low-use regions	74.70 (17.9%)	39.78(17.9%)
Organic	High users	Low users
High-use regions	37.34 (2.8%)	1.56 (2.8%)
Low-use regions	49.21(5.7%)	3.19(5.7%)

Average by cell. Population weight of each cell is indicated in parenthesis. Kruskal-Wallis test for difference across cells $\chi^2(7) = 395.088$; Prob = 0.0001

We run a sensitivity analysis on the impact of the assumptions on the efficiency of the DSS to reduce pesticide use on our results (Figure 4). To do so, we vary the target percentile one can

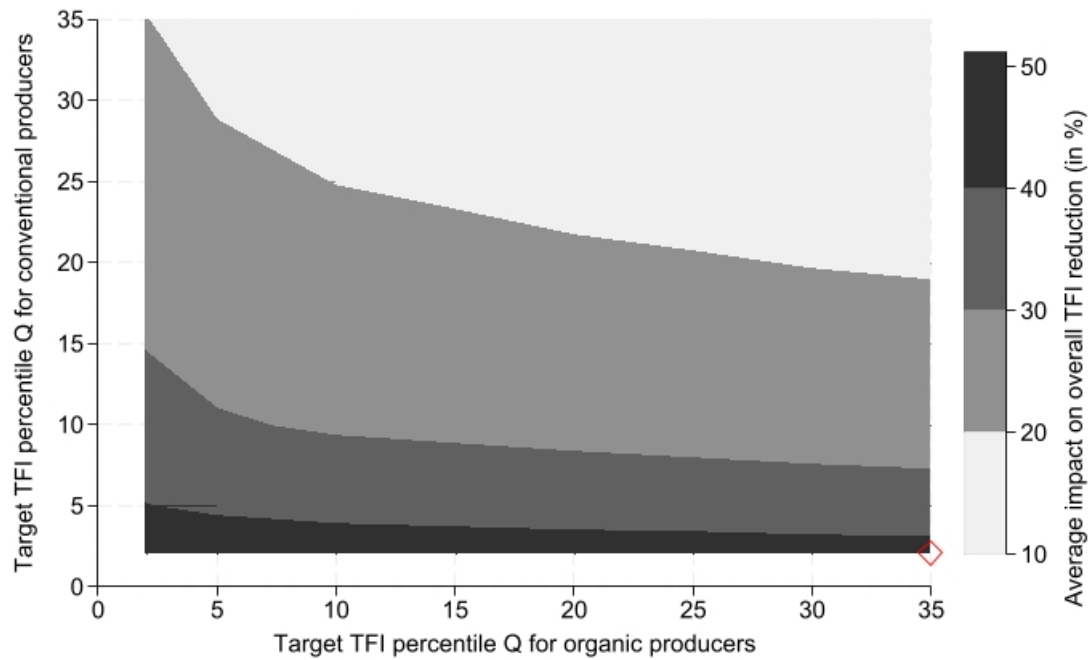
reach with the DSS for both types of practices ($Q_{conventional}; Q_{organic}$). We find that fungicide reduction will be substantial (more than 40%) only if conventional producers using the DSS can reach TFI levels that are lower than the 5% vine growers treating least intensively. This is in line with field experimental observations for the DSS, but underlines the importance of this parameter for results. However, note that even under way less optimistic assumptions the green insurance would still have a very significant impact on pesticide reduction. For example assuming a percentile of 14 instead of 2 for conventional producers would still lead to reductions between 30 and 40%, which are targeted in the French National Action Plans for pesticide reduction. Importantly, the overall impact is less dependent on assumptions regarding the DSS's efficiency for organic producers since the TFI distribution for organic producers is narrower.

We find limited evidence of windfall effects. 23% of the adopters in the sample have a null expected reduction since their TFI corresponds to TFI* (63% of them being organic growers). They would benefit from more secured revenues, partly thanks to the public support of the bonus, without achieving additional fungicide reduction. For conventional producers, the proportion of producers with null reduction potential is not significantly different at the 5% level in the adopters and non-adopters groups. For organic producers, the proportion of producers with null reduction potential is significantly higher in the non-adopters groups. Both results suggest that the scheme does not particularly attract producers likely to benefit from windfall effects.

4.5 Cost-efficiency of public support

Adjusting for sampling bias, for an average annual loss of 10%, the program would cost on average €1457 per hectare and per year. In terms of cost efficiency, the average cost of public bonus subsidy is €104 per hectare for a 1% reduction in TFI. But we find significant differences in the cost and cost-efficiency of green insurance subsidies across the eight cells in Table 8. This heterogeneity is driven by different TFI reduction potential k , but also differences in the financial value of insured yields (since the cost of the bonus is proportional to \bar{y}). Indeed, the financial yield is significantly lower in low-use regions (which is driven either by lower yields in regions

Figure 4: Average potential TFI reduction at the population level: sensitivity analysis according to DSS performance



Note: the target TFI percentile (Q) is the TFI of the Q less-intensive producers in terms of fungicide use, by type of practices (conventional and organic), according to French agricultural practices survey (2019). It is considered as a metric for DSS environmental performance: the DSS performs better (in environmental terms) if one can reach the TFI of a lower percentile of the population.

such as Côtes du Rhône or lower wine value in regions such as Val de Loire or Gaillac). As a result, the public spending to compensate for losses is lower in the low-use regions, compared to high-use regions. This suggests a regionally differentiated policy program in order to increase cost efficiency.

Table 8: Public cost in €/ha for a 1% reduction in TFI

Non-organic	High users	Low users
High-use regions	13 (23.6%)	221 (23.6%)
Low-use regions	16 (17.9%)	34 (17.9%)
Organic	High users	Low users
High-use regions	50 (2.8%)	570 (2.8%)
Low-use regions	15 (5.7%)	145 (5.7%)

Average by cell. Population weight of each cell is indicated in parenthesis. Kruskal-Wallis test for differences across cells: $\chi^2(7) = 75.468$; Prob = 0.0001

4.6 Robustness checks

We apply several tests to check the robustness of the results to different specifications (Appendix F). We find no significant difference with the estimate for the full sample presented in Figure 3 and the estimates for different sub-groups. As a further robustness check, to account for inattention bias, we estimated a 3-classes latent class model with all parameters in one class restricted to zero (Table A.6 in Appendix F). We find that 40.5% of the respondents were classified as making random choices, which is similar to what was found by Malone and Lusk (2018). Estimates for the two other classes remain robust to this specification, but the proportion of respondents sensitive to the green insurance attributes (belonging to class 1) is reduced to 25% (instead of 40% in Table 5) and we find no significant determinants of class 1 membership.

We also tested for overshooting, as defined by Glenck et al. (2023). The criterion compares the highest level of the price attribute with the willingness to pay (WTP) for the bundle of attributes yielding the highest utility (loss-based individual contract with a 65% coverage rate), without including utility captured via alternative specific constant. We find evidence of reasonable overshooting: the average WTP for the bundle of attributes yielding the highest utility is 13.46 (median 2.89). With the highest price level equal to 8, this corresponds to a 68% overshooting magnitude. As a comparison, over the 305 DCE studies considered by Glenck et al. (2023), the mean relative magnitude of overshooting is 337%, with a median of 102%.

5 Discussion

A high pesticide use reduction potential Our results indicate that green insurance is an innovative tool that has the potential to induce a shift in practices towards less pesticide use. More than half of the surveyed French vine growers are interested in green insurance, in particular if insurance contracts are similar to those offered for current multiple-peril crop insurance (i.e. individual and loss-based). We found that producers subscribing to the green insurance scheme can reduce their treatment frequency index by 45% on average. The result relies on assumptions regarding the relevance of DSS performance observed in Nouvelle Aquitaine in 2019 for other regions and years. They should therefore be interpreted cautiously until further data is available. We observe important heterogeneity in adoption and pesticide reduction across different types of production systems and regions.

Producers transitioning to organic grapevine growing are more interested in green insurance and have a lower price elasticity. Reasons could be that they are already more likely to have lower yields (a higher risk of loss, ρ^0 in the model), might be interested in the technical assistance offered by the DSS to comply with the regulation on maximum copper use (European Union 2018), or have more confidence in their ability to safely decrease fungicide use (smaller $\rho^k - \rho^0$).¹⁸ This selection of growers could increase the overall risk to be covered by the insurer, as organic growers already face a higher risk, and reduce the overall environmental performance since the DSS reaches higher TFI reduction for conventional producers. But it also means that green insurance could be an interesting complementary tool to support the political objectives on the up-scaling of organic or pesticide-free production systems (Schebesta and Candel 2020; Möhring and Finger 2022), and secure transitions at a time when market signals are currently negative.

We observe regional heterogeneity in adoption rates and impact in terms of TFI reduction, probably driven by the local fungal pressure and wine value. Such results corroborate findings from the theoretical model on the determinants of the participation constraint. To tailor insur-

¹⁸Given that some learning occurs during the transition, transitioning growers are likely to expect more frequent losses (higher ρ^0) than organic ones, which is consistent, in our model, with an increased likelihood that their participation constraint is satisfied

ance contracts to different circumstances and increase their attractiveness, insurers will have to gather sufficient data to correctly price the contracts. This data is not yet available because not enough growers are making the decision to use very low pesticide levels, and the ones who do probably have specific characteristics. By inducing a switch to greener practices by a sufficient share of farmers, subsidized green insurance can generate data on the actual losses incurred over a few years when using less pesticide. In addition, one may expect the quality of the DSS to improve thanks to a wider pool of farmers providing feedback on the impact of its recommendations. The development of green insurance can improve the information available to farmers, insurers, and public authorities.

A gap between producers' preferences and insurers' opinions Despite high acceptability as assessed in the DCE, green insurance is a new product and providers of green insurance will face contract development costs. Low subscription rates if the contracts marketed do not correspond to the demand would further increase transaction costs and delay learning on the relevance of the scheme to reduce pesticide use. We find that on average, producers prefer individual to group contracts, and loss-based to index-based insurance. On the contrary, the insurers we interviewed believe green insurance should be developed in priority under group and index-based contracts.

Farmers' limited understanding is an important factor in their reduced demand for index insurance (e.g. Cole et al. (2013) and Sibiko et al. (2018) among others). Follow-up questions show that only 2% declared to have already subscribed to an index insurance and only 27% have already heard about this system before. We could not detect a significant effect on knowledge and experience with index insurance on preferences towards such products to cover fungal disease risk, but the direction of the effect is consistent with previous work. This result suggests that extension services and insurers will have to put effort into explaining to farmers how index insurance works, including the basis risk, often mentioned as the major obstacle (Jensen, Barrett, and Mude 2016; Jensen, Mude, and Barrett 2018). In the DCE, the basis risk may have been perceived by respondents as high since we were not very explicit about the specification

of the index. Last but not least, respondents may have not perceived the potential cost-saving associated with index insurance. It was underlined in the presentation of attributes that index contracts might reduce transaction costs, and therefore allow insurers to offer significantly cheaper contracts. But, in the choice cards, it was less explicit since some schemes had both an index-based evaluation of damages and a higher price (for higher coverage).

Moreover, while French farmers frequently complain about private insurance companies, they show no interest in group-based contracts, that could be implemented in the form of a mutual fund, a typically low-cost non-profit organization (Meuwissen, Assefa, and Asseldonk 2013). Beyond farming, group-based contracts are widely used for risk-sharing. They reduce problems of asymmetric information and act as a catalyst for risk prevention and knowledge sharing (Meuwissen, Bottema, et al. 2019). French vine growers' reluctance could be explained by their willingness not to engage in contracts with collective commitments, but previous work with French vine growers has shown that they value collective commitment when it can benefit the environment (Kuhfuss et al. 2016). In the experiment, we defined the likely perimeter for group contracts as the cooperative, the perimeter of the indication of origin or the wine region. But at such a scale, fungal disease risk can be systemic and growers may lack trust in the mutual fund's financial robustness (Giampietri, Yu, and Trestini 2020). Insurance experts generally agree that pools consisting of less than one-third of a sector cannot sufficiently spread the risks and are too small to survive (Meuwissen, Assefa, and Asseldonk 2013). Offering index insurance to groups is foreseen as a promising opportunity to offer insurance products that are both attractive and easy to implement (Trærup 2012; Santos et al. 2021; Meuwissen, Mey, and Asseldonk 2018). Indeed, group index-based insurance can be more attractive if a common risk-sharing pool is set up to transfer excessive payouts, as a remedy to the imperfect correlation between the index and losses. This system could for example be implemented through cooperatives as follows: an index-based contract is signed by a cooperative. If the index triggers the indemnity, payment is made to the cooperative, which then distributes it according to their local understanding of growers' performance for the year. Loss evaluation is then in the hands of the cooperative,

possibly reducing the cost of insurance and the basis risk perceived by growers.

Another option considered by insurers to reduce costs is to integrate climatic and green insurance contracts (Meuwissen, Mey, and Asseldonk 2018). But crop insurance can have unintended effects and lead to pesticide use increases (Möhring, Dalhaus, et al. 2020; Wu 1999; Enjolras and M. Aubert 2020). The coverage of disease risk through green insurance could thus further raise complex cross-effects. In a follow-up question (answered by 241 respondents), 58% declared they would prefer green insurance remaining independent of climatic insurance. But whether contracts should clearly delineate between losses due to direct weather and climate impacts and losses due to indirect consequences of different climatic conditions (such as fungal diseases, which are more likely to develop in humid and warm weather conditions) remains an open question.

Comparison with other pesticide policies We find that green insurance may potentially induce sizable pesticide use reductions. However, cost-efficiency will play an important role in its introduction. Based on sample estimates, the program would cost less than €480 per hectare and per year for half of the adopters (€1580 on average). This is much more costly than other programs designed to reduce pesticides. In 2018, the DEPHY network, a system of farm advisors implemented on a large sample of farms in France, cost €150 per hectare and per year (Lapierre, Sauquet, and Julie 2019). The Agri-environmental scheme (AES) payment to reduce herbicides in French vineyards from 2007 to 2014 ranged from €141 to €350 per hectare and per year. Another AES available to vine growers close to water catchments from 2014 to 2020 provided incentives to reduce TFI up to 80% of the local average TFI for a compensation of €301 per hectare and per year (EAFRD 2014).

However, the relatively low cost of these other programs does not imply a high effectiveness. First, because they attract a very limited number of producers. For example, only around 4,000 hectares out of the 220,000 hectares of vine in the Nouvelle-Aquitaine region (including Bordeaux, Cognac, and Bergerac amongst others) have been engaged in an AES targeting herbicide reduction over the period 2015-2022. Second, participation in the AES does not necessarily in-

fluence management practices. High windfall effects have been reported for some AES schemes (Chabé-Ferret and Subervie 2013; Ait Sidhoum, Canessa, and Sauer 2023). A public subsidy to green insurance bonus is more costly per hectare, but it has the potential to attract more growers and generate more impact in terms of pesticide use reduction. Unfortunately, ex-post evaluations of adoption rates and impact in terms of TFI reduction of other pesticide programs are scarce, limiting the possibility of comparing them with the ex-ante evaluation we conducted. In any case, and whatever the program, the environmental and health benefits associated with pesticide reduction should also be taken into account in these cost-benefit analyses (Finger, Schneider, et al. 2024), such as the reduction in exposure risk offered by the use of the DSS system (Tago, Andersson, and Treich 2014).

We also discussed in the theoretical model that a tax on fungicides, by increasing cost savings from using fewer pesticides, would be complementary to the insurance bonus to foster green insurance adoption. With a lower bonus and a pesticide tax, one could therefore reach similar adoption levels, and increase the cost-efficiency of the scheme.

Other risk management tools than green insurance exist and may better meet some producers' needs. As mentioned by several respondents, the financial risk can be managed by stocking part of the wine of very productive years, to be included in the blend of the following year, as authorized by European law within the framework of inter-branch organizations (European Union 2013). Inter-annual wine transfers between producers (rather than money transfers through insurance indemnity) are preferable when producers fear to loose markets if they have no wine to sell in a given year. Regarding sanitary risks, an alternative to chemical protection is the adoption of resistant varieties (Finger, Zachmann, and McCallum 2023). This alternative instrument has not been mentioned by the interviewed growers but is developing rapidly. Further research is needed to be able to compare the effectiveness and cost-efficiency of short-term solutions such as reducing pesticide use with green insurance and longer-term ones such as the adoption of resistant varieties.

Robustness The robustness of our results relies on the complementary between the theoretical predictions and the empirical test with the DCE. This is particularly relevant when predictions are ambiguous or behavioral factors are coming into play. In particular, we found, both in the theoretical model and empirically, that high-use producers, who tend to face adverse conditions or lack the expertise needed to reduce fungicide use, are less likely to subscribe to green insurance, suggesting that their higher cost savings due to less fungicide use (compared to low-use growers) are not sufficient to counteract the high perceived risk of losses associated with DSS recommendations. The empirical evidence on growers' low interest for index-based contracts is consistent with the model, especially if producers overestimate the probability of losses ρ^k or are pessimistic about the probability of being indemnified ρ^i . This is likely in the absence of detailed information in the DCE on the index specification. Furthermore, we predicted that risk aversion had an ambiguous impact on insurance subscription, especially for index-based insurance. This is consistent with the absence of influence of self-evaluated risk aversion on green insurance adoption in the DCE.

High adoption rates should be taken with a grain of salt given the hypothetical nature of choices in DCEs. Respondents may indeed underestimate the costs of participating in such a new green insurance scheme, including the transaction costs to enroll in the program, but also the opportunity cost of time to understand and enact DSS recommendations. Moreover, one may wonder whether there have been non-attendance of some attributes. In particular, the small effect size of the coverage attribute suggests that respondents have focused more on the certain financial cost of the contract (the premium), and less on the uncertain financial benefit (function of the coverage level). This may also be due to an anchoring effect to the multi-peril insurance coverage levels (70%, which corresponds to the lower level of the green insurance). This level may have been perceived as standard and producers' choices were impacted to a limited extent by higher coverage rates. Note that given that the framing treatment concerned the coverage attribute, this may also explain why we found no significant impact of framing. This null result is nevertheless in line with previous evidence on the limited impact of nudges

on farmers (Davidson and Goodrich 2023, Chabé-Ferret, Le Coent, et al. 2019).

Our study focused on grapevine production in France, where both incentives to use pesticides, and uncertainties about the impact of reducing TFIs on financial yields, are especially high, suggesting that potential adoption of these tools would be even more important for other crops. Future research on green insurance should test results for other regions and crops.

6 Conclusion

Green insurance could be an important tool for supporting farmers' transition to more environmentally friendly production practices, by managing potential economic risks. We provide evidence of French grapevine growers' interest in a green insurance scheme, coupled with free access to a Decision Support System, to secure yields while reducing fungicide use. The insurance provides a (publicly subsidized) bonus to growers who follow reduction recommendations. By providing a secure environment to test reduced pesticide use practices, green insurance coupled with a DSS can help producers revise their perceptions on the number of treatments needed to control fungal pressure. We find that among the 412 surveyed French grapevine growers, 54% are willing to subscribe to a loss-based individual insurance for an annual price of 5% of the insured capital and an 80% coverage of their losses (including the 30% bonus obtained by complying with DSS recommendations). Farmers transitioning to organic farming and organic farmers are more likely to subscribe to green insurance and are less sensitive to insurance price than other producers. More innovative schemes such as group and index-based contracts are less attractive, despite having the potential to reduce the costs of green insurance.


Our results are of direct relevance for policymakers and insurers designing new insurance products to cover disease risks. We find that publicly subsidized green insurance could provide an innovative policy tool to reach ambitious pesticide reduction targets. Extrapolating the results to the population level, we estimate that insured producer would reduce their fungicide treatment by 45% on average, thanks to DSS recommendations. Having in mind the EU Green Deal target of reducing pesticide use by 50% by 2030, green insurance could significantly contribute to the

objective for the wine sector. Our results further indicate a high potential cost-efficiency of such a policy, compared to other policy tools.

Our study has some important limitations that open avenues for future research. We here focus on wine production and France. Grapevines are of high relevance for pesticide use, but results might not easily be extrapolated to other crops or regions, given the peculiarity of agronomic, market, and climatic conditions. However, similar combinations of decision support systems and green insurance could also be of high value in field crops, such as potatoes (e.g., Möhring, Wuepper, et al. 2020b). Moreover, results on pesticide reduction potentials and cost efficiency are based on field trial data for one year and region in France. Future research should therefore extend to other crops and countries and further test the impact of decision support tools on pesticide reduction under real field conditions in heterogeneous environments.

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Appendix

Appendix A: Modelling vine growers' decisions

This appendix presents the proofs of the model developed in section 2.

Loss-based insurance. With loss-based insurance, the indemnity $I = (\alpha + b)l\bar{y}$ is received if and only if $y = (1 - l)\bar{y}$, which happens with probability ρ^k .

The expected utility for a risk-averse producer is

$$\mathbf{EU}_k^{LB} = (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - C^k - P$$

Taking up the contract and following the DSS is profitable if and only if the following participation constraint (PC) is satisfied:

$$\begin{aligned} (PC)^{LB} \quad \mathbf{EU}_k^{LB} &= (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - C^k - P \\ &\geq (1 - \rho^0)u(\bar{y}) + \rho^0 u((1 - l)\bar{y}) - C^0 \\ &\Leftrightarrow \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - \rho^0 u((1 - l)\bar{y}) - (\rho^k - \rho^0)u(\bar{y}) \geq P - (C^0 - C^k) \\ &\Leftrightarrow (C^0 - C^k) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - \rho^0 u((1 - l)\bar{y}) \geq (\rho^k - \rho^0)u(\bar{y}) + P. \end{aligned}$$

Moreover, taking up the insurance contract and complying with the DSS recommendations is more attractive than taking up the contract without following the DSS if and only if the following incentive constraint (IC)^{LB} is satisfied:

$$\begin{aligned} (IC)^{LB} \quad \mathbf{EU}_k^{LB} &= (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - C^k - P \\ &\geq (1 - \rho^0)u(\bar{y}) + \rho^0 u((1 - l(1 - \alpha))\bar{y}) - C^0 - P \\ &\Leftrightarrow (C^0 - C^k) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - \rho^0 u((1 - l(1 - \alpha))\bar{y}) \geq (\rho^k - \rho^0)u(\bar{y}) \end{aligned}$$

Index-based insurance. The incentive constraint is satisfied if the profits above are higher than the ones obtained when taking up the insurance contract but not reducing one's TFI. This strategy provides profits of:

$$\begin{aligned} & \rho_{nl+ni}^0 u(\bar{y}) + \rho_{nl+i}^0 u\left((1 + (\alpha + b)l)\bar{y}\right) \\ & + \rho_{l+i}^0 u\left((1 - (1 - \alpha - b)l)\bar{y}\right) + \rho_{l+ni}^0 u\left((1 - l)\bar{y}\right) - C^0 - \beta P \end{aligned}$$

The incentive constraint that ensures compliance with the DSS thus writes as:

$$\begin{aligned} (IC)^{IB} : & \quad \rho_{nl+ni}^k u(\bar{y}) + \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right) \\ & + \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right) + \rho_{l+ni}^k u\left((1 - l)\bar{y}\right) - C^k - \beta P \\ & \geq \rho_{nl+ni}^0 u(\bar{y}) + \rho_{nl+i}^0 u\left((1 + \alpha l)\bar{y}\right) \\ & + \rho_{l+i}^0 u\left((1 - (1 - \alpha)l)\bar{y}\right) + \rho_{l+ni}^0 u\left((1 - l)\bar{y}\right) - C^0 - \beta P \\ \Leftrightarrow & \quad (\rho_{nl+ni}^k - \rho_{nl+ni}^0) u(\bar{y}) + (\rho_{l+i}^k - \rho_{l+i}^0) u\left((1 - l)\bar{y}\right) \\ & + \rho_{nl+i}^k u\left((1 - (\alpha + b)l)\bar{y}\right) - \rho_{nl+i}^0 u\left((1 + \alpha l)\bar{y}\right) \\ & + \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right) - \rho_{l+i}^0 u\left((1 - (1 - \alpha)l)\bar{y}\right) \geq -(C^0 - C^k) \end{aligned}$$

which can be written as:

$$\begin{aligned} (IC)^{IB} : & \quad (C^0 - C^k) \geq \\ & [\rho_{nl+i}^0 u\left((1 + \alpha l)\bar{y}\right) - \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right)] \\ & + [\rho_{l+i}^0 u\left((1 - (1 - \alpha)l)\bar{y}\right) - \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right)] \\ & + (\rho_{nl+ni}^0 - \rho_{nl+ni}^k) u(\bar{y}) + (\rho_{l+ni}^0 - \rho_{l+ni}^k) u\left((1 - l)\bar{y}\right) \end{aligned}$$

The participation constraint states that taking up the insurance contract and following the

DSS is more profitable than no insurance:

$$\begin{aligned}
(PC)^{IB} : \quad & \rho_{nl+ni}^k u(\bar{y}) + \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right) \\
& + \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right) + \rho_{l+ni}^k u\left((1 - l)\bar{y}\right) - C^k - \beta P \\
& \geq (1 - \rho^0)u(\bar{y}) + \rho^0 u((1 - l)\bar{y}) - C^0 \\
\Leftrightarrow \quad & \rho_{nl+i}^k u\left((1 + (\alpha + b)l)\bar{y}\right) + \rho_{l+i}^k u\left((1 - (1 - \alpha - b)l)\bar{y}\right) \\
& \geq (1 - \rho^0 - \rho_{nl+ni}^k)u(\bar{y}) + (\rho^0 - \rho_{l+ni}^k)u\left((1 - l)\bar{y}\right) + \beta P - (C^0 - C^k)
\end{aligned}$$

Appendix B: Experts forecasts

We conducted a prediction survey in autumn and winter 2022. We present here the questionnaire sent to forecasters and their forecasts. Experts' predictions have been used to formulate hypotheses, as advised by Dellavigna et al. (2019).

B.1. Questionnaire sent to forecasters

We would like your opinion as a professional of the wine sector on the interest that vine growers could have for a new insurance scheme. This scheme would allow to mitigate the risks linked to fungal diseases in a context of limited use of fungicides. Currently, only the climatic risk (frost, hail) is concerned by a subsidized insurance scheme. Your answers are useful for us to guide the decisions of public authorities regarding new tools better adapted to the needs of vine growers.

Our team only includes researchers working for public institutions Our study is totally anonymous and is conducted without any commercial or political purpose.

Thank you for your time. [Institutional logos included here]

A. Your Profile

A1: What is your field of activity?

If you are a vine grower with no responsibility for representing of the profession, please do not answer the survey. You will have the chance to respond to the survey for vine growers during the winter of 2022-2023.

- Production
- Wine commercialisation
- Consulting (oenology, technical support,...)
- Financing (bank, insurance,...)

Research and Development

Other

A2: Can you specify your organization or company?

A3: Do you know the insurable treatment protocol tested by IFV and Groupama on the wine cooperatives of Buzet and Tutiac?

Yes

No

B. The system considered

We are talking about a risk management system for fungal diseases. This insurance scheme is not available for vine growers. Your opinion will help us to think about the interest and the best way to conceive this device.

The scheme provides for:

1. **Financial coverage** for losses due to diseases. The diseases covered are downy mildew, powdery mildew, and block rot.
2. A **decision support system** providing treatment recommendations to reduce fungicide treatments, formulated by the French Institute of Vine and Wine.
3. A **bonus**, funded by the public authorities, if vine growers follow the protocol's recommendations.



Some details:

- The IFV tool models the development of fungal diseases based on field observations and weather data. It advises vine growers on how to carry out fungicide treatments. These decision rules have been thought out beforehand with vine growers.
- According to the tests over 4 campaigns, following this protocol allows to save, depending on the year, between 40 and 70% of fungicides, while still achieving at least 90% of the yield target.
- The scheme is open to all, with or without certification. A specific version of the treatment protocol exists for organic farming.
- Subscription to this compensation scheme for losses due to disease is independent of the multi-risk climate insurance (MRC) which guarantees climatic risks (frost, hail...).
- The practices of the vine growers can be controlled (treatment booklet, visit).

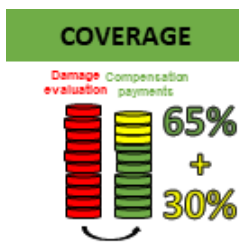
To access to the scheme, vine growers pay a **price** which is a **percentage of their insured capital**.



The insured capital is equal to the insured yield multiplied by the price at which the production is valued.

The subscription is necessarily made for the whole of a wine-producing exploitation.

The **coverage** is a **percentage of the evaluated losses**, without any threshold.



All losses are compensated, according to a basic compensation percentage defined by the contract.

Grapevine growers who respect the treatment protocol (dates, doses) receive a higher coverage compared to those who carry out more treatments. This bonus is funded by the public authorities.

B1: In your opinion, what proportion of vine growers would **never** be interested in such a guarantee (whatever its characteristics and price)? % of vine growers.

B2: For which of the two aspects do you think that the vine growers would be interested in the device?

- Coverage for losses due to fungal diseases.
- Treatment protocol to reduce fungicides while maintaining yields.
- Other:

Comment on your choice here:

B3: The evaluation of the losses can be done:

- **by an expert**, who comes to observe the consequences of the fungal diseases in the vineyard plots and then the harvest
- **by an index** of fungal pressure, based on observations of control vines close to of the vine growers

In your opinion, what proportion of vine growers would prefer a loss-based evaluation rather than an index-based evaluation of losses?

% of vine growers.

B4: Grapevine growers can join the scheme. . .

- **Voluntary** (as for a classic insurance)
- **Compulsory** (as for a mutual fund between vine growers of the same cooperative, appellation or wine area)

According to you, what proportion of vine growers would prefer a voluntary membership rather than a mandatory one as for a mutual fund?

% of vine growers.

Use the criteria below to draw the profile of the winemaker who:

- In your opinion, is most likely to be interested in this type of tool;
- In your opinion, prefers expertise to the index;
- According to you, prefers voluntary membership to compulsory membership (as for a mutual fund between vine growers of the same cooperative, appellation or wine area).

Your answers will be compared to the choices made by vine growers in another survey.

B5: Phyto user profile

Choose the appropriate answer for each row:

	IFT lower than the average of the wine basin	IFT close to the average of the wine basin	IFT higher than the average of the wine basin	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B6: Certification

Choose the appropriate answer for each row:

	HVE	AB	Other certification	No certification	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B7: Commercialisation

Choose the appropriate answer for each row:

	Harvest vinified in individual cellar	Harvest vinified in cooperative cellar	Harvest sold as fresh, juice or grape musts	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B8: Diversification

Choose the appropriate answer for each row:

	Grapevine grower	Polycultivator	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B9: Production mainly in...

Choose the appropriate answer for each row:

	AOC/AOP (protected denomination of origin)	IGP (protected geographic indication)	Without indication	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer vol- untary mem- bership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B10: Using Decision Support System

Choose the appropriate answer for each row:

	Already DSS user	Without DSS	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B11: Insurance

Choose the appropriate answer for each item

	Already insured multi-risk and satisfied	Already insured multi-risk insurance and dissatisfied	Not insured multi-risk climate	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer vol- untary mem- bership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B12: Responsibility

Choose the appropriate answer for each row:

	Owner	Manager	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

B13: Production value

Choose the appropriate answer for each row:

	Production value higher than the average for vine growers in the same wine area	Production value lower than the average for vine growers in the same wine area	No influence
Interested in the insurance scheme	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer expertise to index	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Prefer voluntary membership to membership in a mutual fund	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

C. What parameters?

We would like to know your opinion on the parameters that could make the system attractive to vine growers.

C1: According to you, what minimum coverage and maximum price should be offered to vine growers to make the insurance scheme attractive?

Coverage (in % of assessed loss)

Premium (in % of the insured capital)

C2: According to you, what difference in coverage should be applied between a grower who follows exactly the treatment protocol and one who treats more during a campaign?

% of losses

C3: Do you think that vine growers would be more interested in an insurance scheme...

- with a compensation of $90 - (\text{Bonus})\%$, completed by a bonus of $(\text{Bonus})\%$ if they follow the treatment protocol
- with a compensation of 90% , reduced by $(\text{Bonus})\%$ if the treatment protocol is not followed
- This has no influence.

C4: Do you think that vine growers would be more willing to follow exactly the treatment protocol under an insurance scheme

- with a compensation of $90 - (\text{Bonus})\%$, completed by a bonus of $(\text{Bonus})\%$ if they follow the treatment protocol
- with a compensation of 90% , reduced by $(\text{Bonus})\%$ if the treatment protocol is not followed
- This has no influence.

D. About you

D1: How long have you been working in the wine sector?

Your answer must be between 1940 and 2022.

D3: In which area do you work (department number)?

E. To thank you for your participation

E1: Would you like to participate to a random draw for the first 50 people who completed the entire survey? To be won: Six bottles of Crémant de Loire made for the 50th anniversary of the University.

Yes

No

E2: Please enter your email, the winner will receive an e-mail asking her to indicate her postal address to receive the bottles at home.

E3: Would you like to receive the results of the study by email in 2023?

Yes

No

E4: Please enter your email address to receive the results

F. Comments

F1: Thank you for your answers. They will be compared to the choices made by vine growers in another survey. You can indicate here any reaction or suggestion related to this questionnaire.

Thank you for your time in answering this questionnaire.

If you have any comments, please do not hesitate to contact us: [email address provided]

Thank you for completing this questionnaire.

B.2. Forecast results

We summarize here experts' forecasts on vine growers' preferences collected with the prediction survey. While the prediction survey included more questions, we focus here on the forecasts related to the pre-registered hypotheses.

Experts anticipate more interest for green insurance from vine growers treating less than the average. → Pre-registered hypothesis H3

Concerning the impact of producers and farms' characteristics, most experts forecast that vine growers already committed to and satisfied with a climatic insurance, would be interested by green insurance. → Pre-registered hypothesis H2

According to the expert's estimates, 71% of vine growers would prefer a voluntary individual contract rather than a mandatory group one. → Pre-registered hypothesis H5

On average the experts believe that 64% of vine growers would rather prefer an expert-based insurance than an index-based insurance. → Pre-registered hypothesis H6

Most experts predict that vine growers would be more interested by the green insurance with the bonus framing, but have ambiguous forecasts concerning the impact of framing on compliance with DSS recommendations. → Pre-registered hypothesis H7

Appendix C: Pre-registered hypotheses

The following hypotheses are based on the literature on pesticide use reduction and Agri-Environmental Scheme and insurance contract choices. They are also in-line with results from a prediction survey conducted in autumn and winter 2022 to collect experts' forecasts on vine growers' preferences for the different attributes, and impacts of farm and producers' characteristics on these preferences.

H1: Grapevine growers have a positive willingness to pay for such a green insurance covering yield losses due to fungal diseases.

H2: Risk and producers risk preferences will both influence producers willingness to adopt green insurance and to follow DSS recommendations to reduce their fungicide use.

H3: Self-selection into the scheme: H3a: Grapevine growers who are treating intensively will be (despite characteristics that make them treat more) attracted by the technical and financial assistance provided by the scheme, because this group likely includes the most risk-averse vine growers. H3b: Grapevine growers who are treating less intensively will be the most attracted by the scheme, as they are more likely to receive the bonus and get windfall benefits.

H4: Grapevine growers are more willing to pay for a green insurance contract with better coverage (lower deductible) and lower premium.

H5: Vne growers are less willing to pay for a collective contract, but this effect is reduced for vine growers who are already working together, especially those members of a cooperative.

H6: Grapevine growers are less willing to pay for an index insurance, but this effect is reduced for those who have already experienced such insurance and those more innovation-oriented (proxied by producers' characteristics).

H7: Grapevine growers are more willing to pay for green insurance in the bonus framing, but are less likely to comply with DSS recommendations, compared to the penalty framing.

H8: Green insurance is an effective instrument to achieve fungicide reductions in line with targets of the French National Action Plan (Ecophyto) and the EU green deal.

Appendix D: Framing effect - Results

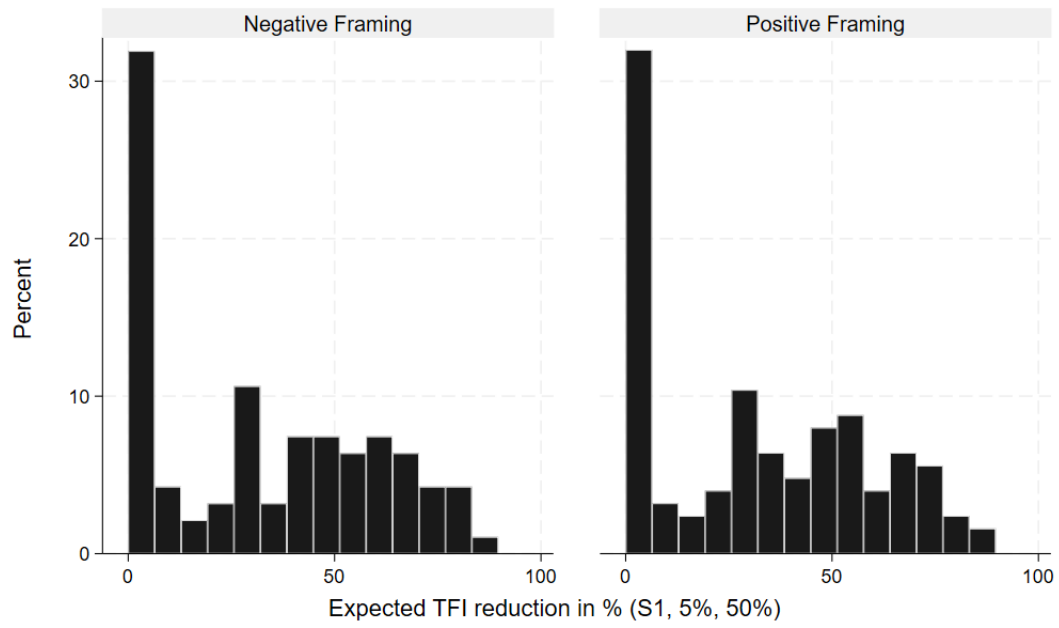
To test for the impact of framing on preferences towards green insurance, we estimate the RPL model for the bonus and penalty framing sub-samples separately. The hypothesis that we have significant effects in presenting the indemnity as a bonus or penalty is verified by the means of a likelihood ratio (LR) test (Höhler and Schreiner 2019 ; Contini et al. 2019). The value of the LR $(-2(-1276.68-(-724.825-516.79)))$ test is lower than the critical value for χ^2 statistic at 5% with 10 degree of freedom (18.307). We can therefore not reject the null hypothesis. This indicates that presenting the indemnity as a bonus or penalty does not significantly change respondents' preferences, even when the scale differences between treatments are controlled for.

Moreover, we verified that the framing has no selection impact: producers subscribing to insurance in the bonus framing group are not significantly different from those in the penalty framing group in terms of TFI reduction potentials (Figure A.1), according to the Kruskal–Wallis equality-of-populations rank test ($\chi^2(1) = 0.057$; Prob = 0.8112)

A.1: Framing impact on preferences for green insurance

	Bonus framing		Penalty framing	
	Mean	SD	Mean	SD
ASC	-3.090*** (-4.57)	2.871*** (3.65)	-1.169 (-1.39)	8.353*** (4.67)
Group	-0.425** (-2.56)	1.240*** (4.59)	-0.882*** (-4.71)	0.800** (2.39)
Index	-0.418*** (-3.30)	0.639** (2.38)	-0.347** (-2.51)	0.443 (1.21)
Coverage	0.0254** (2.45)	0.0510*** (3.62)	0.0245** (2.38)	0.0375** (2.17)
Price	-1.341*** (-3.87)	2.736*** (5.70)	-2.564*** (-4.15)	-2.509*** (-5.95)
N	2772		2172	
LL	-724.825		-516.795	

A.1: Fungicide use reduction reached with green insurance and the DSS in the bonus and penalty framing subgroups - for those willing to subscribe to green insurance



Appendix E: Adoption rate by regions

We observe in Table A.2 that there are less adopters in regions where wine value is higher (Côte-du-Rhône Nord, Charentes, Champagne, Bourgogne) or disease pressure is lower (Languedoc, Provence). When the production value is high, the uninsured part of losses $(1 - \alpha - b)l\bar{y}$ dampens the incentive to get the green insurance. Where the risk of losses is lower, the premium P appears too costly and the cost savings from following the DSS are limited (low $C^0 - C^k$). In both cases, the participation constraint (PC) is less likely to be satisfied. Nevertheless, due to the interplay of different regional characteristics, there is no significant difference in the adoption rate between the regions where regional average TFI is below the national median (Low-use regions) compared to the other regions (High-use regions). Organic growers (including those in transition) are particularly likely to subscribe to green insurance if their are high users in high-use regions (Table A. 3).

A.2: Respondents and adopters by region

Region	Low use/High use+	Adopter*	Sample	Population**
Bouches-du-Rhône	Low-use	0,00%	0,24%	1,12%
Dordogne	High-use	0,00%	0,97%	0,92%
Côtes-du-Rhône Nord	Low-use	25,00%	0,97%	2,69%
Charentes	High-use	38,23%	8,25%	7,51%
Champagne	High-use	44,00%	12,14%	21,44%
Languedoc hors PO	Low-use	46,43%	13,59%	23,20%
Bourgogne	High use	46,66%	7,28%	3,72%
Provence (Var-Vaucluse)	Low-use	48,15%	6,55%	9,19%
Alsace	Low-use	50,00%	2,43%	4,92%
Corse	High-use	50,00%	0,97%	0,58%
Côtes-du-Rhône Sud	Low-use	50,00%	1,94%	
Bordelais	High-use	55,36%	13,59%	10,41%
Pyrénées-Orientales	Low-use	60,00%	1,21%	2,09%
Val de Loire	Low-use	63,88%	17,48%	2,55%
Beaujolais	High-use	66,00%	2,18%	5,81%
Lot-et-Garonne	High-use	66,66%	0,73%	0,71%
Cher	Low-use	66,67%	1,46%	0,52%
Bugey Savoie	High-use	71,43%	1,70%	0,57%
Jura	Low-use	77,77%	2,18%	0,45%
Gaillac	Low-use	85,71%	1,70%	0,29%
Gers	High-use	85,71%	1,70%	0,85%
Cahors	High-use	100,00%	0,73%	0,44%

+ "Low-use regions" are the regions where regional average TFI are below the national median (according to French agricultural practices survey 2019)

* Adopter of the S1 contract (5% price and 50% coverage)

** Grapevine growers population according to French agricultural census 2020.

A.3: Adoption rates of the S1 contract (5% price and 50% coverage)(with population weight in parenthesis)

Non-organic	High users	Low users
High-use regions	55.17 (23.6%)	53.3 (23.6%)
Low-use regions	67.5 (17.9%)	51.72(17.9%)
Organic	High users	Low users
High-use regions	66.7 (2.8%)	39.13 (2.8%)
Low-use regions	56.52(5.7%)	51.02(5.7%)

Kruskal-Wallis test for difference across cells $\chi^2(7) = 6.382$; Prob = 0.496

Appendix F: Robustness checks

We run the same RPL model than the one presented in the main text (Figure 2) to different subgroups. In column (1), we first exclude responses to the first choice card seen by respondents, to account for learning effects. In column (2), we exclude responses to the last choice card in order to check for a lassitude effect. In column (3), we exclude respondents who indicated no interest in the scheme before answering choice cards, since they are more likely to have provided random answers. In column (4), we exclude those who have always opted-out. Finally, in column (5), we exclude respondents who read the description of attributes, including the video presenting the DSS, in less than thirty seconds, which is considered as too short for a comprehensive overview of the green insurance scheme. In column (6), we exclude the 36 respondents who were interviewed face to face in order to keep only self-completed responses.

A.4: RPL estimates for subgroups

Model	(1)Excl first choice (Learning effects)	(2)Excl last choice (Lassitude effect)	(3)Excl. not inter- ested	(4)Excl. al- ways opted- out	(5)Excl. low reading time	(6)Excl. Face to face
Mean						
ASC	-3.134*** (-4.19)	-2.143*** (-3.30)	-4.970*** (-5.52)	-2.547*** (-6.18)	-4.355*** (-3.37)	-2.177*** (-3.56)
Group	-0.642*** (-4.36)	-0.641*** (-4.76)	-0.751*** (-4.83)	-0.577*** (-5.17)	-0.960*** (-2.78)	-0.621*** (-4.88)
Index	-0.456*** (-3.80)	-0.436*** (-3.83)	-0.450*** (-3.88)	-0.370*** (-4.26)	-0.614** (-2.12)	-0.387*** (-3.97)
Coverage	0.0289*** (3.39)	0.0197** (2.26)	0.0258*** (2.95)	0.0249*** (3.87)	0.0118 (0.68)	0.0236*** (3.56)
Price_Inv	-1.844*** (-4.92)	-1.888*** (-5.61)	-1.824*** (-6.05)	-2.009*** (-8.28)	-1.191*** (-2.77)	-2.125*** (-5.73)
SD						
ASC	6.300*** (6.37)	5.743*** (6.54)	-3.466*** (-4.64)	-1.426*** (-3.87)	2.991** (2.16)	6.035*** (7.65)
Group	1.148*** (4.80)	0.680** (2.49)	1.283*** (5.11)	1.040*** (6.30)	1.725*** (3.84)	1.113*** (5.68)
Index	0.725*** (2.85)	0.652** (2.50)	0.639*** (2.83)	-0.501** (-2.57)	1.357*** (3.16)	0.557*** (2.63)
Coverage	0.0269 (1.45)	0.0421** (2.42)	0.0360*** (2.95)	0.0276*** (4.34)	0.00906 (0.52)	0.00756 (0.42)
Price_Inv	2.760*** (8.27)	2.014*** (8.67)	-1.779*** (-7.25)	-1.022*** (-5.35)	1.943*** (4.84)	2.748*** (7.39)
N	3708	3708	2544	3324	972	4512

t statistics in parentheses : * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

A.5: Criteria for determining the optimal number of classes in the Latent Class model

Number of classes	Log-likelihood (LL)	AIC	BIC	Prediction accuracy: Average latent class posterior probability
2	-1294.102	2618.203	2678.52	98.24%
3	-1257.064	2564.128	2664.654	93.96%
4	-1219.810	2509.619	2650.355	89.69%

Notes: AIC (Akaike Information Criterion) is $-2(LL - j)$ where j is the number of parameters to be estimated in the model; BIC (Bayesian Information Criterion) is $-LL + (k/2) \ln(N)$ where N is the number of observations.

Appendix G: Survey dissemination

A.7: Channels used for survey dissemination

Chanel	Targeted population
Agriconomie, an on-line shop selling inputs and equipment to agricultural producers	17000 vine growers who had bought at the shop or opened their newsletter in the last 2 months
Vitisphere (main professional information website for the wine industry in France)	Readers of the website
Farm cooperatives national network (section vine growers)	Regional federations, who have forwarded the email to vine growers
The National and Nouvelle Aquitaine regional Federation of Organic Agriculture. (section vine growers)	Organic vine growers
Regional Branch of Producers Organisations (Loire Valley, Bordeaux, Côtes du Rhône, Cognac, Champagne, Bourgogne...)	Grapevine growers receiving newsletters
Agricultural chambers national network	Technical advisors in different wine regions, who have forwarded the email to vine growers
VitiREV Project network	Grapevine growers receiving the newsletter
National network of <i>independent vine growers</i>	Grapevine growers receiving the newsletter
De Sangosse (major agricultural inputs supplier)	Clients of the company, in particular those buying biological control products
Face to face interviews in wine fairs and other professional events	
Personal contacts of the authors	

A.6: Latent class with random response class

	Class 1 (25%)	Class 2 (34.5%)	Class 3 (Random choice) (40.5%)
ASC	-4.502*** (-4.18)	0.542 (0.51)	-1.220*** (-5.66)
Group	-1.986*** (-5.27)	-0.284 (-0.56)	0 (.)
Index	-1.140*** (-4.41)	-0.631 (-1.34)	0 (.)
Coverage	0.0446*** (3.33)	0.00449 (0.21)	0 (.)
Price	-0.421*** (-4.78)	-0.577*** (-3.66)	0 (.)
	Probability to belong to class 1	Probability to belong to class 2	(class 3 reference)
Organic	0.468 (0.69)	-0.717 (-1.52)	
Organic_transition	-0.846 (-0.87)	-2.547*** (-3.38)	
Other certification	-0.413 (-0.63)	-1.080* (-2.56)	
Sanitary strategy	0.238 (1.02)	-0.253 (-1.60)	
Constant	-0.965 (-1.00)	1.632** (2.71)	
N	4944		

t statistics in parentheses * p<0.05, ** p<0.01, *** p<0.001

Appendix H: English version of the vine grower survey

We are looking for your point of view on new tools, designed to help you compensate the risks associated with fungal diseases.

Currently, only the climatic risk (frost, hail) can benefit from a subsidized system. However, the risks of losses associated with diseases also prevail for the wine sector, even more in a context of reduction of phytosanitary products use.

By responding to this study today, you are helping to guide the decisions of public authorities to design and implement new tools better adapted to the needs of vine growers.

Our team includes only researchers working for public institutions. Our study, totally anonymous and validated by an ethics committee, is conducted without commercial or political purposes.

Thank you for your time.

This project is funded by: [institutional logos included]

INTRODUCTION

Expected answers

We are expecting answers from people in charge of financial decisions in a vineyard, but also in charge of decisions related to phytosanitary treatments. Do not hesitate to answer as a duo with the financial manager and the technical manager.

You will need to provide your Fungicide Treatment Frequency Index (TFI) for the last three years (it will not be disclosed). You will then be able to compare it with regional averages.

Please have this information ready before you start. If you do not already have access to TFI, you can calculate it [here](#). To get your Fungicide TFI from this calculator, enter only your fungicide treatments. The first value in the table (1st line "TFI") is your fungicide TFI.

Data management

This study is anonymous. Neither your name nor your company's name will be asked. In accordance with the principles of open science, and in compliance with the General Data Protection Regulation, data will be anonymized before archiving and made available for scientific

use.

Duration

The survey takes about 12 minutes. You can stop at any time and return to the questionnaire later, by clicking on the same link. To return to the questions on the previous page, click on "previous" at the bottom left of each page but do not go back on the navigator, otherwise your answers will not be saved.

Contact

For any question : [contact email provided]

B1: Consent

- I confirm that I have read and understood the above information. I am at least 18 years old and I give my consent to participate in this study.
- I do not give my consent.

(The survey ends here if the answer is "I do not give my consent.")

Filters

C1: Are you responsible for the financial management decisions of a vineyard ?

- Yes
- No

(The survey ends here if the answer is "No")

C2: Are you in charge of decisions regarding vineyard management, including treatments?

- Yes, I am responsible for vineyard treatments.
- Yes, I participate in the reflections on the treatments of the vineyard.
- No, someone else is in charge and I am not consulted.

(The survey ends here if the answer is "No, someone else is in charge and I am not consulted.")

C3: What is your role in the vineyard ?

- Owner
- Manager (employee)
- Other :

C4: How long have you been working in viticulture ?

If you have been working in viticulture for less than one year, put 0.

Years

Profile of the vineyard

D1: In which grapevine-growing area is your vineyard located (or most of it if it is located in several regions)?

- Alsace
- Beaujolais
- Bordelais
- Bouches-du-Rhône
- Bourgogne
- Bugey-Savoie
- Cahors
- Champagne
- Charentes

- Cher
- Corse
- Côtes-du-Rhône Nord (northern part of the departments 07 and 26)
- Côtes-du-Rhône Sud (southern part of the departments 07 and 26)
- Dordogne
- Gaillac
- Gers
- Jura
- Languedoc hors Pyrénées-Orientales
- Lot-et-Garonne
- Provence (Var-Vaucluse)
- Pyrénées Orientales
- Val de Loire

D2: Are the products from your vineyards commercialized under one or more of these designations?

- Protected denomination of origin (AOP/AOC)
- Protected geographic indication (IGP)
- Without indication (e.g. Vin de France or Vin de la Communauté Européenne)

D3: What is the size of your vineyard ?

Only numbers are accepted

Surface dedicated to wine grape production (ha)

Surface dedicated to other productions (ha)

D4: What is your dominant commercialization mode ?

- Grape
- Bulk
- Bottle
- Mixed (specify in the comment area)

D5: Are you in one or more of these situations ?

- Member of a cooperative
- Member of a CUMA
- Member of a GIEE
- Member of a collective sales outlet
- Elected official/vine grower representative

Phytosanitary strategy

E1: Concerning the management of vine diseases, for example to test new protection practices, how would you position yourself between very careful and risk-taking?

1	Very careful	2	3	4	5	6	7	8	9	10	very risk-taking
	<input type="radio"/>		<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>		<input type="radio"/>

E2: Does your vineyard or wine production follow one or more of these specifications?

- Certified High Environmental Value (Level 3)
- Certified Organic Agriculture
- Certified Demeter or Biodyvin
- Certified Terra Vitis
- My vineyard was certified OA but is no longer certified
- In conversion towards Organic Agriculture
- None
- Other :

E3: Do you know your Fungicide TFI for 2020, 2021 and 2022?

Reminder: If you do not already have access to it, you can calculate it here [link provided]. To get the fungicide TFI from this calculator, please fill in only your fungicide treatments. The 1st value of the table obtained (1st line "TFI") will then be your fungicide TFI.

- Yes
- No

Over the last 3 years, what has been the fungicide TFI (including copper) of your vineyard?
Please also count the fungicides authorized in Organic Agriculture such as copper.

[if E3 == Yes]

	Fungicide TFI	
E4:	2020	
E5:	2021	
E6:	2022	

[if E3 == No]

E7: Can you at least tell us the number of fungicide applications (including copper)?

2020	
2021	
2022	

E8: Considering the specificities of your farm, how would you rate your use of fungicides compared to other vine growers in your area?

- You think that your use is much lower than that of others.
- You think your use is slightly lower than others.
- You think your use is about average.
- You think your usage is slightly higher than others.
- You think your usage is much higher than others.

E9: Was your farm engaged in a AECM contract (Agri-Environmental and Climatic Measure of the CAP) with a commitment to reduce the Treatment Frequency Index over at least part of the period 2015-2022?

- Yes
- No

E10: What is your current state of mind regarding your plant protection strategy?

- For the moment, reducing my use of fungicides is not my priority.
- I have already reduced my use of fungicides, it is difficult to go further.
- I am trying to reduce my use of fungicides, but I find it complicated.

- I am in the process of reducing my fungicide use.

E11: Do you currently use a decision support system (DSS) to adjust your phytosanitary treatments ?

By the term DSS, we are talking about the different digital tools offered to vine growers today, from various organizations (agriculture chambers, technical institutes, private companies), to advise you in the adjustment of phytosanitary treatments.

- Yes and I am satisfied
- Yes and it is not very satisfactory
- No, not for now but I am thinking about it
- No, I don't use it and I'm not interested in it

The insurance scheme

We would like to know your opinion on an insurance scheme, still in reflection, for managing the risks associated with fungal diseases.

*[The participants were assigned randomly to questions on the scheme in the bonus **or** the penalty framing. Hereafter will be displayed the presentation of both bonus and penalty framing but the participants only read the parts they were assigned to.]*

[BONUS framing] **The insurance scheme provides:**

1. **Financial coverage** for annual losses due to diseases. The diseases concerned are downy mildew, powdery mildew and black rot.
2. The provision of a **treatment protocol** formulated by the IFV (French Institute of Vine and Wine) to reduce fungicide treatments as safely as possible.
3. A **financial bonus**, financed by the public authorities, if the vine growers follow the recommendations of the protocol.

[PENALTY framing] **The insurance scheme provides:**

1. **Financial coverage** co-funded by public authorities for annual losses due to diseases. The diseases concerned are downy mildew, powdery mildew and black rot.
2. The provision of a **treatment protocol** formulated by the IFV (French Institute of Vine and Wine) to reduce fungicide treatments as safely as possible.
3. If vine growers prefer not to follow the DSS recommendations, and use more fungicides, a **penalty** applies such that the **coverage is lowered** (no co-funding by public authorities in this case).

Access to the insurance scheme is subject to the payment of a fee. The subscription is necessarily made for the whole of a vineyard. The access to the decision support system communicating the treatment protocol is included in the subscription fee.

You can view the testimony of a vine grower who has experienced this insurance scheme as part of the VitiREV project in New Aquitaine (Right click on the image).



The video is also available [here](#)

Some details:

- The insurance scheme adoption is open to all, with or without certification. A specific version of the treatment protocol exists for vineyards in organic agriculture.
- The practices of the vine growers can be controlled (treatment notebooks, visits).

- Subscription to this insurance scheme for losses due to diseases is independent of the multi-risk climate insurance (MRC). You may wish to subscribe to one or the other, or both but with no obligation.

Insurance scheme versions

From the general insurance scheme presented above, several versions can be considered.

Your opinion will allow us to think about the interest and the best way to conceive this insurance scheme if it is one day proposed to the vine growers.

Here are the possibilities considered:

TYPE OF CONTRACT which can be:

Individual



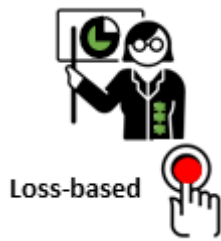
Each vine grower decides **individually** whether or not to subscribe to the insurance (as for a classic insurance).

Collective

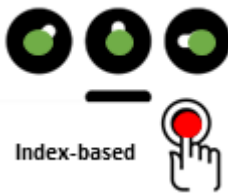


The vine growers subscribe to a **group** contract, for example within the framework of a mutual fund between vine growers of the same cooperative, appellation or wine basin. In this case, membership is compulsory for all the vine growers in the group concerned.

DAMAGE EVALUATION:

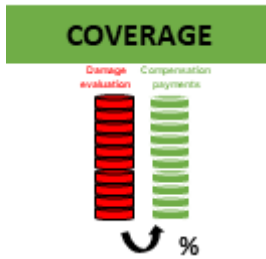


Your real losses are assessed by an **expert**, who comes to observe in your plots the consequences of fungal diseases and then the harvest. The amount of the compensation depends on the expert's evaluation of your real losses. The expertise allows an evaluation of the losses specific to your farm but is subject to the subjectivity of the expert and is more expensive than the index evaluation.



Your losses are estimated on a local fungal pressure **index** measured, for example, in control vineyards near your home. The amount of compensation depends on the value of this index. Your real losses will sometimes be higher and sometimes lower than in the control vineyards, but the index can help to reduce insurance costs and make the assessment of losses more objective than an expert evaluation.

COVERAGE:



[BONUS FRAMING] The **coverage** is a percentage of assessed losses (between 40 and 65% of losses). No triggering threshold is applied. The coverage will be higher for vine growers respecting the treatment protocol (dates, doses) and not carrying out any treatment other than those recommended by this protocol, thanks to an additional 30% bonus financed by the public authorities. With the bonus, the total coverage is between 70% (40%+30%) and 95% (65%+30%) of the losses.

[PENALTY FRAMING] The **coverage** is a percentage of assessed losses (between 70 and 95% of losses). No triggering threshold is applied. A part of this coverage is funded by public authorities. A penalty of 30% (the part normally funded by public authorities) will lower the total coverage for vine growers preferring not to follow the treatment protocol (dates, doses) and carrying out other treatments than those recommended by this protocol. With the penalty, when not following the treatment protocol, the coverage is between 40% (70%-30%) and 65% (95%-30%) of the losses.

PREMIUM:



Subscribing to insurance is costly and the **price** is defined in % of the insured capital. The insured capital is equal to the insured yield multiplied by the price value of the production. To help your choice, in addition to the mention of the % of the insured capital (between 3 and 8%), a corresponding amount (in €/per hectare) will be provided, depending on the price at which you declare to value your production and the yield you have declared to insure.

Simulation

Let's simulate the case of your vineyard.

Imagine that you want to sign up for this insurance scheme, please indicate below the parameters you would choose to view the compensation amounts at the bottom of the page.

If you have several values in mind, please give us the one for your main production.

H1: On average over the last 5 years, at what price do you value your production (in €per hectoliter of wine)?

We need this information to provide you with compensation amounts that are appropriate for your situation. If you do not know or do not wish to give an exact amount, please give an estimate.

(€/hL)

H2: What level of return do you want to ensure ?

You can set it to your potential return. The only constraint is that this level has been reached at least once in the last 5 years.

(€/hL)

H3: The following table shows you the level of compensation you would receive under this insurance scheme for an amount of losses of 10% due to fungal disease.

As a reminder, following this DSS treatment protocol associated with the device allows to save, depending on the year, between 40 and 70% of fungicides, while allowing to reach at least 90% of the yield objective. Losses will therefore rarely exceed 10%.

[BONUS FRAMING] Estimation of the compensation for **YOUR** vineyard:

	COVERAGE	COVERAGE
Coverage rate	 <small>Damage evaluation</small> <small>Compensation payments</small> 40% + 30%	 <small>Damage evaluation</small> <small>Compensation payments</small> 65% + 30%
Basis coverage in €/ha	_____€/ha (40%)	_____€/ha (65%)
Coverage with the bonus of 30% in €/ha	_____€/ha (70%)	_____€/ha (95%)

[PENALTY FRAMING] Estimation of the compensation for **YOUR** vineyard:

	COVERAGE	COVERAGE
Coverage rate	 <small>Damage evaluation</small> <small>Compensation payments</small> 70% - 30%	 <small>Damage evaluation</small> <small>Compensation payments</small> 95% - 30%
Basis coverage in €/ha	_____€/ha (70%)	_____€/ha (95%)
Coverage with the penalty of 30% in €/ha	_____€/ha (40%)	_____€/ha (65%)

H4: What do you think?

- I might be interested in this device, depending on how it is set up and its price.
- A priori, I am not interested in such a device to manage the risk of losses due to fungal diseases, whatever its price and the way it is set up.

[For the 4 following choices, the cards are displayed here in the bonus framing only but participants to the survey were assigned to bonus or penalty and saw the corresponding choice cards]








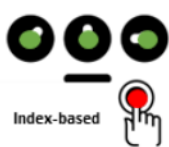



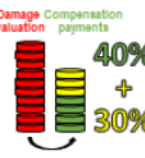




Choice 1/4

On each of the following 4 pages, you will see two insurance schemes with different characteristics (Scheme A and Scheme B, shown below in columns).

Even if these schemes do not exist for now, please choose between the two schemes the one you would prefer for YOUR vineyard, as you would do in reality if these schemes were offered to you. It is like choosing between two menus in a restaurant: Drink/Entry/Main Course/Dessert, without being able to choose each menu item separately. If you are not interested in any of the proposed features, you can choose "No Guarantee".

There is no right or wrong answer. Keep in mind the situation of YOUR vineyard. This is what will allow us to more reliably assess what is best for each individual situation.







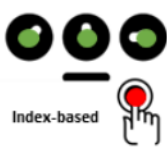

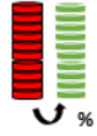

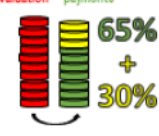
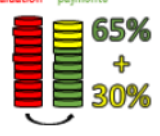




You can review what each pictogram means by clicking on (i). This opens a new information tab that you must close to return to the questionnaire.

	A	B
TYPE OF CONTRACT  	Collective 	Individual 
DAMAGE EVALUATION  	 Loss-based	 Index-based
COVERAGE  	 50% + 30%	 40% + 30%
PRICE  	 8 % of insured capital	 5 % of insured capital
For your vineyard	(Average yield* Value* 0.08) €/ha	(Average yield* Value * 0.05) €/ha

	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Choice 2/4







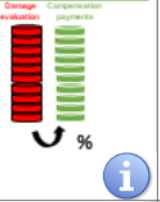





You have to make a choice again. You do not have to worry about your previous choice to choose on this page because the scheme presented are different. You can review what each pictogram means by clicking on (i).

	A	B
TYPE OF CONTRACT  	Individual 	Collective 
DAMAGE EVALUATION  	 Index-based	 Loss-based
COVERAGE  	 65% + 30%	 65% + 30%
PRICE  	 8 % of insured capital	 5 % of insured capital
For your vineyard	(Average yield* Value* 0.08) €/ha	(Average yield* Value * 0.05) €/ha

	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Choice 3/4








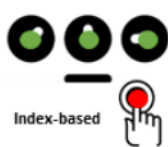








You have to make a choice again. You may find this a bit long but we need your choice on several possible configurations of the scheme. Thank you.

	A	B
TYPE OF CONTRACT 	Collective 	Individual 
DAMAGE EVALUATION 	Index-based 	Loss-based 
COVERAGE 		
PRICE 	 5 % of insured capital	 3 % of insured capital
For your vineyard	(Average yield* Value* 0.05) €/ha	(Average yield* Value * 0.03) €/ha

	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Choice 4/4

Thank you for choosing again. This is the last one

	A	B
TYPE OF CONTRACT  	Individual 	Collective 
DAMAGE EVALUATION  	 Loss-based	 Index-based
COVERAGE  	 40% + 30%	 55% + 30%
PRICE  	 3 % of insured capital	 6 % of insured capital
For your vineyard	(Average yield* Value* 0.03) €/ha	(Average yield* Value * 0.06) €/ha

	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

To better understand your choices

You have almost finished, thank you! A few last questions to help us to understand your choices and your situation.

M2: What are the reasons you chose not to purchase any of the guarantees presented? [Only

for respondents who always choose no guarantee]

You may choose up to 3 reasons and rank them in order of importance.

- I have few fungal diseases in my vineyards
- I am not interested in reducing my use of fungicides
- I manage my phytosanitary risk myself without needing anyone else
- I have organized my activity to support a financial loss one year (Individual Complementary Volume, diversification, provision...)
- I do not trust that I will be correctly compensated in case of losses
- I do not see the interest because I already have a multi-risk climate insurance
- I imagine very heavy administrative procedures
- The price is too high
- Other (please specify in the next question)

M3: Please specify for what other reason you have chosen not to purchase any of the guarantees presented.

M4: The insurance scheme has been designed to give you flexibility in following the DSS recommendations.

[BONUS] Reminder: If you do not follow the treatment protocol, you will receive the basic coverage. If you follow the treatment protocol (dates, doses) and do not perform any treatments other than those recommended by the protocol, you would receive the basic coverage + bonus.

[PENALTY] Reminder: If you follow the DSS recommendations (dates, doses) and do not perform any treatments other than those recommended by the protocol, you would receive the

maximal coverage. However, if you do not follow the DSS recommendations, a penalty would lower the coverage and you would receive 30% less than the maximal coverage.

If you had the opportunity to actually subscribe to this tool, how would you use the DSS recommendations?

[BONUS]

- Not following the DSS recommendations at the beginning of the season, and therefore only receiving basic coverage for losses.
- Follow the DSS recommendations at the beginning of the season and stop if they do not suit you.
- Follow the DSS recommendations until the end of the campaign to be sure to benefit from the bonus, in addition to the basic coverage.

[PENALTY]

- Not following the DSS recommendations at the beginning of the season, and therefore receiving the coverage reduced by the penalty of 30% in case of losses.
- Follow the DSS recommendations at the beginning of the season and stop if they do not suit you.
- Follow the DSS recommendations until the end of the campaign to be sure to benefit from the maximal coverage.

M5: In the schemes we have proposed to you, the assessment of losses was sometimes based on an index. Were you aware of this type of insurance before you answer this survey?

With index insurance, the compensation depends on an index and not on your own performance.

- No, I did not know about it

- Yes, I have heard of it but I have never bought it
- Yes, I have already taken out index insurance (or parametric insurance) in a professional or private context.

M6: What was the main reason for your interest in the insurance scheme we presented?

- Compensation for fungal disease losses
- The DSS recommendations to reduce my fungicides while maintaining yields
- Both are equally important for me
- Other:

M7: If you were insured against climatic risks (with multiple risks, hail or frost guarantee) at least once in the last 5 years, what was your level of satisfaction?

- I have not been insured
- Very satisfied
- Quite satisfied
- Quite dissatisfied
- Very dissatisfied

M8: It is possible that this fungal disease insurance system could be systematically associated with an MRC contract. What would you prefer?

- That the scheme we have presented to you remains independent of the MRC.
- That this system and the MRC are associated in a global coverage contract

Respondent's profile

N1: Did you study viticulture ?

Yes

No

N2: What is your level of education ?

No diploma

Primary school certificate (CEP)

Brevet des collèges (BEPC)

CAP, BEP

Bac or equivalent

1st cycle (BTS, DUT, DEUG, Bachelor or equivalent)

2nd, 3rd cycle or Grandes Ecoles (Master, DESS, DEA, Engineer, Doctorate, or equivalent)

Other :

N3: What is your year of birth ?

N4: Are you ?

Male

Female

Other

N5: Before answering this survey and watching the video, had you ever heard of the experimentation conducted within the framework of Vitirev by IFV and Groupama in Buzet and Tutiac ?

Yes

No

Fungicides per grapevine growing area

After answering all these questions, you may be interested in knowing the fungicide use of other vine growers in your wine basin. We share with you here data from the agricultural practices survey (2019) published by the French Ministry of Agriculture. In your area (**NAME OF THE REGION**, in 2019, the average Fungicide-Bactericide TFI for all vineyard was **REGIONAL TFI** and the average number of treatments was **NUMBER OF TREATMENTS In THE REGION**. [For organic producers, we also indicated the numbers for organic plots]

Comments

P1: Thank your for your participation. Your comments and suggestions in the space below will be very useful for the analysis of the results.

Do not hesitate to write us anything that comes to your mind!

P2: If you wish to receive the results of the study by email in 2023, please enter your email address here.

It will be stored separately from your responses and deleted once the survey is over.



Thank you for your time in answering this questionnaire.

For all question or remark: [contact email provided]

[institutional logos included here]