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

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## Abstract

Green insurance can help producers manage the risks of transitioning to more environmentally friendly practices. We investigate the uptake determinants 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 out insurance offering compensation for yield losses caused by the failure to contain diseases of a Decision Support System targeting pesticide-reduction. Green insurance can be a cost-effective tool for achieving the EU ambitious pesticide objectives, with an average 45% reduction in fungicide use for adopters.

**JEL codes:** Q18, Q14, D81, C99

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

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## 33 1 Introduction

34 Pest management is central for ensuring crop yield and quality (Savary et al. 2019) and its  
35 importance is expected to further increase under climate change (Chaloner, Gurr, and Bebbler  
36 2021). Current pest management strategies are mainly based on pesticide use, with increasing  
37 evidence of pesticides' adverse effects on the environment and human health (IPBES 2019; Geiger  
38 et al. 2010; Edlinger et al. 2022; Willett et al. 2019; Snelders et al. 2012). As a consequence,  
39 reducing pesticide use and risks has become an important public policy goal on regional and  
40 global levels (Möhring, Ingold, et al. 2020 ; Möhring, Kanter, et al. 2023).

41 Decision support systems (DSS) for farmers to optimally time applications according to  
42 actual local disease pressure have the potential to reduce pesticide use while maintaining yield  
43 levels (Pertot et al. 2017; Chen et al. 2020; Anastasiou et al. 2023, and fungicide in particular  
44 (Lázaro, Makowski, and Vicent 2021). However, their uptake is often low. One important  
45 reason is that expected risks of yield losses are perceived as higher when adapting management  
46 strategies (Gent, De Wolf, and Pethybridge 2011, Shtienberg 2013; Möhring, Wuepper, et al.  
47 2020).

48 Green insurance, which insures potential yield losses when switching practices, is not cur-  
49 rently included in policy toolboxes, despite its potential to increase farmers' uptake of DSS-based  
50 crop protection strategies. With green insurance, the insured producer receives financial com-  
51 pensation in case of yield losses caused by the failure of best management practices (here the  
52 inability of the DSS to contain diseases). <sup>2</sup> If producers have biased perceptions regarding the  
53 effects of new practices on the level and variability of yields or profits (Feather and Amacher  
54 1994), green insurance could help them revise these perceptions by allowing them to try these  
55 practices risk-free (Mitchell and Hennessy 2003; C. Aubert et al. 2020). In other risk areas, it  
56 has been shown that sub-optimal insurance levels are observed when agents face an explicit or

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<sup>2</sup>To limit moral hazard, contracts include requirements to provide 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.

57 implicit cost to discovering the true probability of losses, but public subsidy can trigger optimal  
58 insurance decisions (Kunreuther and Pauly 2004). It suggests that a subsidy for green insurance  
59 could be needed. Compared to agri-environmental schemes (AES), subsidizing green insurance  
60 can be more cost-effective since public support is triggered only for actual losses (Baerenklau  
61 2005), and the level of support required to induce participation by risk-averse producers does  
62 not need to include a risk premium.

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

74 Here we assess the effect of different insurance designs on acceptability, as well as the potential  
75 impact of a subsidized green insurance, targeting fungicide use in French viticulture. Grapevine  
76 production is globally among the most pesticide-intensive and economically relevant crops, and  
77 therefore represents a key entry point to reduce pesticide use in agriculture. In France, the  
78 iconic wine production covers only 3.3% of the agricultural area but is responsible for 14.4%

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<sup>3</sup>For 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. Within the VitiREV project, in France, 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, a proof of viticulture actors' interest in such contracts.

79 of total agricultural pesticide use (Butault et al. 2010). Fungicides represent more than 80%  
80 of pesticides used on vines in France (French agricultural ministry 2022). Due to their high  
81 technical efficacy and low cost, they are sometimes referred to as a very attractive “insurance”  
82 (although they are more adequately termed a prevention mechanism than an insurance properly  
83 speaking).<sup>4</sup> In our analysis, we begin with developing a theoretical model to explain decisions to  
84 subscribe to green insurance and to comply with DSS recommendations (therefore reducing the  
85 protection offered by chemical pesticides). We then conduct a large discrete choice experiment  
86 with 412 French grapevine growers on the uptake and design of the insurance and combine it with  
87 field experimental data on the pesticide use reduction potential. We evaluate the acceptability  
88 of both loss-based and index-based insurance, since the latter is perceived as having a large  
89 potential, also in developed countries, to contribute to better farm-level risk management and  
90 more efficient use of natural resources (Dalhaus, Musshoff, and Finger 2018). Doing so, we  
91 contribute to the very narrow literature on insurance covering pest attacks and diseases, which  
92 accounts for only 0.9% of the agricultural insurance literature (Vyas et al. 2021).

93 Adjusting for sampling bias, we find that between 48% and 60% of the vine growers are  
94 likely to subscribe to the green insurance, depending on contract design and prices. Producers  
95 transitioning to organic certification are more interested in the contract. This result suggests  
96 that green insurance could – in addition to intensive margin effects on pesticide intensity – also  
97 have extensive-margin effects: it could help reduce pesticide use by supporting transitions to  
98 organic farming. Clear preferences emerge for contract design: all producers exhibit less interest  
99 in group and index-based contracts. Using data from field experiments on the DSS impact on  
100 fungicide use, we estimate that adopters could reduce their fungicide treatments by 45% on  
101 average. The chosen set-up would entail higher potential subsidy costs, compared to existing  
102 policy tools in France, but also a higher pesticide reduction potential. Our results remain valid  
103 throughout a series of robustness checks.

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<sup>4</sup>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.

104 This paper is structured as follows. In Section 2, we present the insurance scheme and  
105 model vine growers' decisions to subscribe to green insurance. In Section 3, we explain the DCE  
106 approach and describe the experimental setting and methods used for data analysis. Results are  
107 presented in Section 4 and further discussed in Section 5.

## 108 **2 Modelling vine growers' decisions**

109 We analyze the conditions under which a risk-neutral producer will choose to subscribe to a green  
110 insurance scheme, that partly covers yield losses due to fungal diseases in grapevines. The scheme  
111 entails free access to a DSS that provides treatment recommendations based on climatic and  
112 fungus pressure information. If producers follow the DSS recommendations, a public subsidy is  
113 added to the indemnity paid by the private insurer (which is independent from compliance with  
114 DSS recommendations). By subsidizing indemnities rather than the premium, public money  
115 is not disbursed for each policy-holder, but only for those suffering a loss.<sup>5</sup> Directing public  
116 support to increasing the indemnity is more efficient than reducing the premium (or paying  
117 a fixed subsidy as in an AES) when vine growers are risk-averse or pessimistic about losses  
118 associated with greener practices since it induces participation at a lower cost. Vine growers  
119 tend to apply fungicides too early in the season and repeat applications as soon as the previous  
120 application has been washed away by rain, whatever the actual disease pressure – thus they over-  
121 treat (Davy et al. 2020). The subsidy provides an incentive to producers to follow the DSS, even  
122 when it recommends treating less than they would have done, thus reducing the externalities of  
123 pesticide use.

124 Pesticide use is measured by the Treatment Frequency Index (TFI), i.e. the applied quan-  
125 tities over the course of an agricultural season normalized by their standard treatment dosage  
126 (Lechenet et al. 2017). We focus on changes in pesticide use per hectare, i.e. intensive-margin  
127 effects of the insurance scheme.<sup>6</sup>

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<sup>5</sup>In the EU, multi-peril crop insurance premia are subsidized, but compensation rates are considered too low to foster adoption (Descrozaillaie 2022).

<sup>6</sup>Previous studies have found that risk management tools can also have important extensive margin effects

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

## 130 **2.1 The features of a green insurance contract**

131 A green insurance contract is characterized by its price  $P$  (per unit of insured capital), and the  
132 way the indemnity  $I$  is computed and granted.<sup>7</sup> The indemnity typically does not fully cover  
133 losses: contracts entail a deductible, to induce farming efforts.<sup>8</sup> To incentivize producers to  
134 reduce fungicide use, the insurance scheme entails a bonus in the form of increased indemnity,  
135 financed by public authorities, for vine growers respecting the treatment protocol (timing, doses)  
136 provided by the DSS, and not carrying out any treatment other than those recommended by  
137 this protocol. This is verifiable since it is mandatory for producers to record data on treatments  
138 (date, product, quantity) and legal audits take place.

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

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(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 conditions, such as organic production, might be possible.

<sup>7</sup>In 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  $I$ .

<sup>8</sup>Here, the green insurance is intended to induce a shift towards greener, IPM practices, which can increase yield losses, so the deductible runs contrary to the green objective. However, it remains needed to avoid negligent care.

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

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

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<sup>9</sup>We 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).

<sup>10</sup>Mutual 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.



## 164 2.2 Modelling the impact of pesticide reduction on profits

165 The producer's financial yield without pesticide reduction is  $\bar{y}$ . Reducing treatment intensity  
166 entails the risk of production losses or deterioration of grape quality, at rate  $l \in ]0, 1]$ , that reduces  
167 financial yield to  $(1-l)\bar{y}$ . This happens with a probability that decreases in treatment intensity.<sup>11</sup>  
168 Each producer's conditions vary with regard to fungal disease. These conditions translate into  
169 an initial fungicide treatment frequency index  $TFI$ , that the producer chooses if they do not  
170 contract the green insurance. This level is (weakly) higher than the environmentally optimal  
171 one,  $TFI^*$ , which is the lowest achievable treatment level for the targeted yield ( $TFI^* \leq TFI$ ).  
172 We assume that this optimal level is achieved when one follows DSS recommendations.

173 The percentage of reduction in fungicide use reachable thanks to the DSS is  $k \equiv (TFI -$   
174  $TFI^*)/TFI$ . Reducing fungicides by  $k\%$  reduces the financial costs of applying fungicides,  
175 denoted  $C^k$ . To simplify, we assume that a producer not following DSS recommendations will  
176 not reduce its pesticide use at all ( $k = 0$ ). In that case, the cost of applying fungicide is  $C^0 > C^k$ .

177 The probability of facing losses  $l$  is  $\rho^k$ . We assume  $\rho^k$  is increasing in the reduction of treat-  
178 ment intensity  $k$ , since for a given  $TFI^*$ , producers with higher initial TFI are less experienced  
179 with low-fungicide management practices. While overestimation of probabilities cannot be sys-  
180 tematic in an expected utility model, producers may overestimate the risks from a lower TFI,  
181 compared to the true probability of losses as assessed by experts (e.g., on research plots).

182 We focus here on the analysis for a risk-neutral producer. The case of a risk-averse producer  
183 is detailed in Appendix A. Under risk neutrality, the expected profit of a producer reducing  
184 her pesticides use by  $k > 0$ , thanks to the DSS but in the absence of insurance, would be  
185  $EU_k^{No} = (1 - \rho^k)\bar{y} + \rho^k(1 - l)\bar{y} - C^k = \bar{y}(1 - \rho^k l) - C^k$ .

186 Most French vine growers currently do not use such a DSS despite its low cost.<sup>12</sup> We therefore

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<sup>11</sup>We assume that the probability of a loss depends on treatments but not the extent of the loss. Because we consider risk-neutral farmers in the main text, this has no impact on our description of the choice made by the grower.

<sup>12</sup>The DSS used in the green insurance experimentation run since 2019 in the Bordeaux area, Decitrait, is available at a fixed price of about €250, which is quite small compared to expected cost savings of about €200 per hectare for a 50% reduction in TFI.

187 assume that the following inequality holds:  $\mathbf{E}U_0^{No} > \mathbf{E}U_k^{No}$ , that is:  $(\rho^k - \rho^0)l\bar{y} > C^0 - C^k$ .  
 188 The cost savings on fungicides are not enough to compensate for the higher risk of losses when  
 189 reducing one's TFI, even with the help of the DSS. This is why additional incentives are needed,  
 190 such as those provided by a conditional green insurance.

### 191 2.3 Modelling the subscription to green insurance

192 We assume that  $\bar{y}$  is both the maximum yield and the one insured under the contract, at price  
 193  $P$ . The indemnity  $I$  is paid depending on i) whether there are actual losses ( $l > 0\%$ ) in the case  
 194 of loss-based insurance, or ii) whether the realization of an index reaches a threshold, in the case  
 195 of index-based insurance. The insurance coverage is  $\alpha$  in  $[0,1[$  (due to the positive deductible). If  
 196 the producer follows DSS recommendations and thus reaches  $TFI^*$ , her indemnity is increased  
 197 by a bonus  $b$  funded by public authorities, so her indemnity is equal to  $\alpha + b$  % of losses. We  
 198 assume that  $\alpha + b < 1$  so that losses are never fully covered by the contract. We define the  
 199 participation and incentive constraints for a risk-neutral producer for both types of insurance:  
 200 loss-based and index-based. Appendix A. details the more general case of a risk-averse producer  
 201 and contains proofs and illustrative simulations.

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

$$\mathbf{E}U_k^{LB} = \bar{y}[1 - \rho^k l(1 - (\alpha + b))] - C^k - P$$

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

The producer's participation constraint  $(PC)^{LB}$  to the insurance contract is therefore met  
 if the expected profit without insurance  $\mathbf{E}U_0^{No}$  is lower than the expected profit with insurance,

that is if:

$$(PC)^{LB} : [\rho^0 - \rho^k(1 - \alpha - b)]l\bar{y} \geq P - (C^0 - C^k)$$

or equivalently

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

204 Participation is ensured if the cost savings on fungicides plus the expected indemnity compensate  
 205 for the higher risk of losses plus the insurance premium.

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

$$(IC)^{LB} : (C^0 - C^k) + \rho^k bl\bar{y} > (\rho^k - \rho^0)(1 - \alpha)l\bar{y}.$$

206 The green insurance will indeed induce a reduction in TFI if the savings on fungicides and the  
 207 bonus compensate for the higher risk of losses. Recall that we assume the cost savings are not  
 208 sufficiently attractive in the absence of insurance. With green insurance, the foregone revenues  
 209 in case of losses are reduced, and even more with the bonus triggered by compliance with DSS  
 210 recommendations. The larger the bonus  $b$ , the smaller the residual losses borne by the producer,  
 211 and the more likely it is that the producer prefers to follow the DSS and reduce her TFI. The  
 212 bonus is therefore an effective complement to the green insurance in inducing fewer treatments.

213 The bonus thus causes an increase in both participation and compliance with the DSS  
 214 recommendations. It helps make the insurance contract more attractive and more effective.  
 215 The intuitions are similar under risk-aversion (cf. Appendix A.).

216 If individual experience with fungicide reduction is limited or the DSS does not manage to  
 217 reduce loss frequency ( $\rho^k$  is high), producers will be both less likely to participate and less likely  
 218 to comply with the DSS due to the increase in residual losses. A countervailing effect arises from

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

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

229 **Index-based insurance** The indemnity is triggered by the value of an index, built in order  
 230 to correlate with the realization of yields, but correlation is imperfect. The premium  $P$  equals  
 231 to  $\beta P$ , with  $\beta \leq 1$ , since index-based insurance is assumed to be less costly to implement.

232 We define four scenarios corresponding to discrete states of nature (as in Clarke 2016 and  
 233 Lichtenberg and Iglesias 2022). Associated probabilities are denoted  $\rho_{A+B}^k$  where  $A \in \{l, nl\}$   
 234 takes the value  $l$  in the event of a loss and  $nl$  otherwise, and  $B \in \{i, ni\}$  takes the value  $i$   
 235 in the event of the index triggering the indemnity, and  $ni$  otherwise (cf table A.1). The total  
 236 probability of a loss is  $\rho^k \equiv \rho_{l+i}^k + \rho_{l+ni}^k$  and the total probability of receiving an indemnity is  
 237  $\rho^i \equiv \rho_{l+i}^k + \rho_{nl+i}^k$ . The probabilities with which losses are suffered but no indemnity is paid, and  
 238 vice-versa, are an essential determinant of the insurance properties of the index-based contract.

Under index-based insurance, expected profits are equal to the actual yields in the two states  
 of nature, plus the indemnity when triggered by the index, minus the costs of pesticides and  
 insurance. The expected profit for the risk-neutral producer is  $\mathbf{EU}_k^{IB} = (1 - \rho^k)\bar{y} + \rho^k(1 - l)\bar{y} +$   
 $\rho^i(\alpha + b)l\bar{y} - C^k - \beta P$ , or equivalently

$$\mathbf{EU}_k^{IB} = \bar{y}[1 - (\rho^k - \rho^i(\alpha + b))l] - C^k - \beta P$$

The participation constraint is

$$(PC)^{IB} : (C^0 - C^k) + \rho^i(\alpha + b)l\bar{y} \geq (\rho^0 - \rho^k)l\bar{y} + \beta P$$

239 that is: as in the case of loss-based insurance, the expected indemnity plus the cost savings on  
240 fungicides must compensate for the higher risk of losses plus the insurance premium.

The incentive constraint for a risk-neutral producer is

$$(IC)^{IB} : (C^0 - C^k) + \rho^i b l \bar{y} \geq (\rho^k - \rho^0) l \bar{y}$$

241 where the only insurance term playing a role is  $b$ . The savings on treatments and the bonus in  
242 case of indemnification should exceed the increase in losses. Contrary to the case of loss-based  
243 insurance, the probability with which the indemnity is paid is independent from compliance  
244 with the DSS.<sup>13</sup> But receiving the bonus depends on this compliance. A subsidy to reduce the  
245 premium, granted to all subscribers, would not improve compliance, contrary to the bonus. Our  
246 results therefore show that a green index insurance, in order to maximize chances of inducing  
247 the adoption of greener practices, should be clearly conditional on these practices. Because the  
248 bonus is paid *ex-post*, it is a more efficient form of subsidy than a reduction in the premium, even  
249 if this reduction was also made conditional on compliance (because it would have to be adjusted  
250 months after the premium has been paid, which would create implementation difficulties).

251 Comparative statics are similar to loss-based insurance, but low DSS performance in terms  
252 of reducing the frequency of losses (high  $\rho^k$ ) makes both participation and compliance less  
253 attractive and does not change the probability of receiving the compensation.

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<sup>13</sup>The probability of obtaining the indemnity and the indemnity paid by the insurer both depend only on the index and not on treatments. So the expected value of the indemnity cancels out in the incentive constraint: it is paid exactly in the same way whether treatments have been reduced or not. This is different for loss-based insurance as the probability of actually suffering losses, and therefore obtaining an indemnity, does depend on whether the farmer has reduced treatment intensity.

**Loss-based vs Index-based insurance** The index-based insurance contract is more attractive to a risk-neutral producer than the loss-based one if and only if

$$\mathbf{E}U_k^{IB} \geq \mathbf{E}U_k^{LB} \Leftrightarrow (\rho^i - \rho^k)(\alpha + b)l\bar{y} + (1 - \beta)P \geq 0.$$

254 Index-based insurance is thus always more attractive than loss-based insurance to a risk-  
 255 neutral producer if the probability of indemnity  $\rho^i$  is larger than the probability of actual losses  
 256  $\rho^k$ , or if the index-based contract is sufficiently cheaper.

257 If producers *overestimate* the probability of losses  $\rho^k$ , they will tend to find loss-based insur-  
 258 ance more attractive. Moreover, our model predicts that the growers further away from *TFI\**  
 259 will be less likely than the other growers who depend on the same index (same  $\rho^i$ ) to prefer  
 260 index-based insurance since they face a higher probability of losses  $\rho^k$ .

261 Under risk aversion, the analysis is more complex since the index increases the variability  
 262 in the producer's return: it creates a very positive state where indemnity is received in the  
 263 absence of losses and a very negative state in which no indemnity is received despite losses.  
 264 Although an increase in variability is costly to a risk-averse producer, the index-based insurance  
 265 can still be more attractive if the probability of receiving a bonus even when not suffering losses  
 266 ( $\rho_{nl+i}$ ), is sufficiently large. Knowing the producer's risk-aversion is not sufficient to determine  
 267 the overall effect, since it depends on both the shape of the utility function and the beliefs about  
 268 the probabilities of the four states. The more pessimistic the producer is about  $\rho^i$ , the less  
 269 attractive the index-based insurance, as the variance effect will tend to dominate.

## 270 **2.4 The need for an empirical test**

271 The model allows us to explore how the decision to subscribe to a green insurance is impacted  
 272 by the probability and value of losses ( $\rho^k l\bar{y}$ ), the increase in risk due to pesticide use reduction  
 273 ( $\rho^k - \rho^0$ ), as well as by the cost savings from pesticide use reduction ( $C^0 - C^k$ ). We presented  
 274 the impact of some insurance characteristics such as how damage is evaluated, the coverage  $\alpha$   
 275 and bonus  $b$  rate, and the premium  $P$ . Comparative statics are presented in Appendix A.

276 The model focuses on one source of heterogeneity across producers, based on production  
277 context and expertise: the initial fungicide treatment frequency index ( $TFI$ ), which impacts  
278 the probability of losses when less fungicide is used ( $\rho_k$ ). Other producers' characteristics such  
279 as risk-aversion or attitudes towards digital farming may also impact the decision to subscribe  
280 to the green insurance scheme under study. To account for this larger set of factors, we assessed  
281 the impact of insurance and producers' characteristics on subscription decisions through a choice  
282 experiment. The design is detailed in the next section.

### 283 **3 Method**

284 To analyze preferences for a green insurance which is not available at the time of the study,  
285 we rely on a Discrete Choice Experiment (DCE). DCEs are particularly valuable for investi-  
286 gating individuals' preferences in hypothetical decision-making situations, when purchase or  
287 adoption data are not available (Louviere, Hensher, and Swait 2000). The method has been  
288 previously used to evaluate *ex-ante* programs targeting pesticide use reduction. For example,  
289 in grapevine production, Kufhuss et al.(2016) and Lapierre et al.(2023) rely on DCE to ana-  
290 lyze the attractiveness of innovations in AES design, to better account for uncertainty on the  
291 costs and benefits associated with the adoption of new practices for herbicide reduction. The  
292 method has also been used to analyze preferences for insurance schemes conditional on compli-  
293 ance with specific farm practices. Jorgensen et al.(2020) study the willingness to pay (WTP) of  
294 Danish crop producers for an insurance contingent on investing in sustainable soil management;  
295 and Heikkilä et al.(2016), that of Finnish producers for animal-disease insurance, conditional  
296 on fulfilling bio-security requirements to reduce sanitary risks. Both include the contract price  
297 as monetary attribute and estimate the impact of best management practice requirements on  
298 WTP. Jorgensen et al.(2020) also estimate the impact of the insurance type (yield vs rainfall),  
299 while Heikkilä et al.(2016) include an attribute on the insurance provider (private insurer vs  
300 mutual fund). In the next sections, we present our experimental design, data collection process  
301 and methods for data analysis.

### 302 3.1 Choice experiment design

303 Four attributes presented in Table 1 characterize the different types of green insurance systems  
304 tested in the choice experiment: individual or group contracts, loss-based or index-based damage  
305 evaluation, level of coverage and premium. The first two correspond to binary qualitative  
306 dimensions and the other two to financial attributes, with four levels for each. Attributes  
307 and levels have been chosen to be relevant and realistic, taking into account literature and  
308 experience of pioneering contracts in the South West of France (VitiREV). We have then verified  
309 the experimental design with experts, including insurers, vine growers, and agronomic advisers.  
310 Finally, the attributes have been tested in two pilots in November 2022 and May 2023, with  
311 respectively 24 and 43 producers. The design has been pre-registered.<sup>14</sup>

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

321 Grapevine growers following DSS recommendations receive an additional 30% compensation,  
322 financed by public authorities. This amount was determined with policymakers and insurers and  
323 we decided not to vary it in order to reduce design complexity and to be able to analyze the  
324 impact of the total coverage (including the bonus) on the willingness to subscribe to insurance.  
325 Producers can choose to stop following DSS recommendations during the year if they turn  
326 out to be incompatible with their farm objectives and aversion to risk, which is an interesting  
327 flexibility for growers and possibly a factor of attractiveness. We also do not vary the level of

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<sup>14</sup><https://osf.io/mbvpa>



328 best practice requirements, contrarily to Jorgensen et al.(2020) and Heikkilä et al.(2016), since  
329 partial adoption of DSS recommendations is unlikely to reach the environmentally optimal TFI  
330 and will lead to more subjective and complex control by insurers.

331 Behavioral interventions can be effective in increasing the adoption rate of programs aimed  
332 at influencing producer practices (Ferraro et al. 2022; Serfilippi, Carter, and Guirkinger 2020).  
333 In particular, we know that equivalent descriptions of outcomes using different framing can  
334 result in different choices (Tversky and Kahneman 1981). There is mixed empirical evidence on  
335 the effectiveness of positively-framed versus negatively-framed information in influencing pro-  
336 environmental choices (Lopes, Tasneem, and Viriyavipart 2023). We contribute to this field of  
337 research, by assessing whether a different framing of the bonus incentive has an impact. To do so,  
338 we rely on a split sample approach, comparing a bonus and penalty framing (Tonsor 2018). In the  
339 bonus framing, the insurance coverage rate is presented as a base indemnity plus a 30% bonus  
340 in case of full compliance with DSS recommendations. In the penalty framing, the coverage  
341 is presented as the full indemnity minus a 30% penalty in case of non-compliance with DSS  
342 recommendations. From the behavioral literature, we know that the penalty framing is likely to  
343 reduce willingness to participate in the scheme (due to loss aversion since non-compliance with  
344 DSS recommendations reduces compensation). On the other hand, loss aversion can reinforce  
345 the incentive to comply with DSS recommendations. As a result, we expect vine growers to be  
346 more willing to pay for green insurance in the bonus framing, but less likely to comply with DSS  
347 recommendations, compared to the penalty framing.

348 We created a Bayesian D-efficient design using NGENE on the basis of prior results from  
349 the pilot survey. To make the presented alternatives as realistic as possible, restrictions were  
350 included in the design: we rejected choice cards where the index insurance is more expensive  
351 than the loss-based insurance, unless it provides better coverage. This resulted in a design with  
352 12 choice cards, divided into 3 blocks of 4 cards. Moreover, we control for order effects due to  
353 learning and lassitude by having 3 other blocks with the same choice cards, but presented in a  
354 different order. To measure framing effects, the 3x2 blocks are duplicated (6 with the penalty

355 version of the indemnity attribute, and 6 with the bonus version). Thus, subjects were randomly  
 356 assigned to one of the 12 blocks. Figure 1 shows an example of a choice card, with two insurance  
 357 contracts labeled “A” and “B” and an opt-out option.

Figure 1: Example of choice card




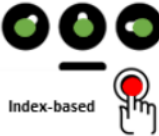


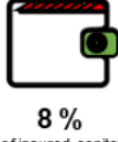
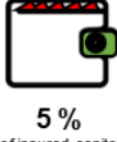
	A	B	
<b>TYPE OF CONTRACT</b>	<b>Collective</b> 	<b>Individual</b> 	
<b>DAMAGE EVALUATION</b>	<b>Loss-based</b> 	<b>Index-based</b> 	
<b>COVERAGE</b>	 50% + 30%	 40% + 30%	
<b>PRICE</b>	 8 % of insured capital	 5 % of insured capital	
For your vineyard	(Average yield* Value* 0.08 ) €/ha	(Average yield* Value * 0.05) €/ha	
	A	B	None
My choice	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Table 1: Attributes and levels

Attributes	Levels		
Type of contract	<p><b>Individual:</b> Each vine grower decides individually whether or not to subscribe to the insurance (as for a classic insurance).</p> <p><b>Collective:</b> 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><b>Loss-based:</b> 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><b>Index-based:</b> 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" style="width: 100%;"> <tr> <td style="width: 50%; vertical-align: top;"> <p><b>Bonus framing</b> Base indemnity + <b>Bonus</b> 40+30%,50+30%,55+30%,65+30%</p> <p>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.</p> </td> <td style="width: 50%; vertical-align: top;"> <p><b>Penalty framing</b> Total indemnity - <b>Penalty</b> 70-30%,80-30%,85-30%,95-30%</p> <p>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.</p> </td> </tr> </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>	<p><b>Bonus framing</b> Base indemnity + <b>Bonus</b> 40+30%,50+30%,55+30%,65+30%</p> <p>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.</p>	<p><b>Penalty framing</b> Total indemnity - <b>Penalty</b> 70-30%,80-30%,85-30%,95-30%</p> <p>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.</p>
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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>		

## 358 **3.2 Data collection**

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

362 The survey was administered online to around 20,000 vine growers (on some 59,000 vine-  
363 growing farms in France), via a company selling inputs and material for vineyards and several  
364 other channels (the list of all these channels is available in Appendix G). The growers received  
365 no financial incentive to participate, but were told that their answers were important to design  
366 future pesticide policies. We received 412 complete answers (participation rate of approximately  
367 2%).

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

## 374 **3.3 Data analysis**

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

### 378 **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:

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

379 The expected profit is a function of observable attributes  $V_{ist}$  plus an unobserved random com-  
380 ponent  $\epsilon_{ist}$  (the stochastic error term).  $X_{ist}$  refers to the vector of levels of the attributes, i.e.  
381 the insurance scheme characteristics. We also include in  $X_{ist}$  an Alternative Specific Constant  
382 (ASC) equal to one for the status quo alternative of not entering into any of the proposed con-  
383 tracts. The price and coverage for each alternative are specified as a continuous variable. For  
384 the other attributes, we include one dummy variable for each level of the attribute described  
385 in Table 1 except one. This excluded level per attribute represents the reference level for each  
386 attribute.

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

395 From RPL estimates, we obtain individual parameters for each attribute, and can calculate  
396 the utility of each respondent for different insurance types. In our analysis we focus on the three  
397 insurance schemes the most likely to be offered on the market. Scheme 1 (S1) is an individual  
398 and loss-based insurance: this disease insurance could be offered with similar features as the  
399 current multiple-peril crop insurance available to vine growers in France. Scheme 2 (S2) is an  
400 individual index-based insurance. Scheme 3 (S3) is a group index-based insurance.<sup>15</sup>

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<sup>15</sup>One 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

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

### 407 3.3.2 Impact on fungicide use

408 We then assess the potential of green insurance to reduce fungicide use. We assume that a  
409 grower willing to contract the insurance and to follow DSS recommendations can reach a  $TFI^*$   
410 equal to those of the growers constituting the lower part of the TFI distribution in the same  
411 area, for the same type of practices (conventional or organic).  $TFI^*$  is thus considered region-  
412 and practice (organic vs. conventional)-specific, as agronomic intuition and data on different  
413 TFI levels across French regions suggest.<sup>16</sup>

414 In the field experiment conducted in the VitiREV project on around a hundred hectares  
415 in the South West of France over the 2019-2022 period, growers have used the DSS under  
416 study here (C. Aubert et al. 2020). Organic vine participating growers reduced their fungicide  
417 use less than their conventional peers. This can be measured with reference to the survey on  
418 practices in vine growing conducted by the French Ministry of Agriculture for the same year as  
419 the VitiREV experiment (French agricultural ministry 2022):  $TFI^*$  is equal to the TFI of the  
420 second percentile in the same region for non-organic producers, and to the TFI of the thirty-fifth  
421 percentile for organic producers ( $Q_{conventional} = 2$ ;  $Q_{organic} = 35$ ).<sup>17</sup> This difference between

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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.

<sup>16</sup>Note that in the theoretical model,  $TFI^*$  was defined as the lowest achievable treatment level for the targeted yield. We therefore assume that this level can be empirically approximated by the treatment levels achieved by the group of most efficient producers of the respective population.

<sup>17</sup>In 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

422 organic and conventional viticulture is due to the different models used by the DSS. As organic  
 423 winegrowers can only rely on preventive products (as opposed to curative), the DSS advises them  
 424 to start chemical protection earlier. Following the assumptions on  $TFI^*$ , for each respondent,  
 425 we can calculate the TFI reduction potential  $k$  in % from their current TFI (average over the  
 426 last 3 years).

427 To adjust for sampling bias and extrapolate our results to the population of French vine  
 428 growers, we simulate the insurance uptake and impact at the national scale by approximately  
 429 correcting for the sampling bias (over-representation of organic farmers). We define eight cells  
 430 characterized by three variables: whether the farm follows organic practices or not, whether  
 431 it is located in a high or low fungicide use region, and whether the farm has a high or low  
 432 TFI compared with the other producers in the same region with the same type of practices.  
 433 To calculate the weights, we allocate the 57,878 French vine growers to the 8 cells (Table 2).  
 434 The 22 French wine regions are ranked according to the average fungicide TFI in the region.  
 435 We name “high-use regions” the eleven regions with the highest average TFI. The number of  
 436 organic producers in each region is obtained from a national database covering organic producers  
 437 (Agence Bio 2020). This number is then divided into two groups: high-users are those with a  
 438 higher average TFI than the region median in the last 3 years for the same type of practices.

Table 2: Share of producers in each cell, used as weights to adjust for sampling bias and extrapolate results at population level (n=57878)

<b>Non-organic</b> (n=48034)	High users	Low users
High-use regions	23.6%	23.6%
Low-use regions	17.9%	17.9%
<b>Organic</b> (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.

439 We then transpose the cell-specific adoption rate and average impact of green insurance on  
 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.

440 fungicide use to the population, accounting for the weight of each cell. Finally, we conduct  
441 a range of sensitivity analyses on the underlying assumptions on the efficiency of the decision  
442 support system to reduce producers' pesticide use.

### 443 **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% :

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

444 where  $k_i$  is the pesticide use reduction of grower  $i$  and  $\bar{y}_i$  their insured capital. The cost for  
445 public authorities is the bonus  $b$  equal to 30% of the expected losses, which are assumed to equal  
446 10% of insured capital annually ( $\rho_k l = 0.1$ ), in line with DSS predictions. We assume that the  
447 incentive constraint is satisfied for all growers, who are thus all eligible for the bonus.

## 448 **4 Results**

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

### 455 **4.1 Descriptive statistics**

456 The final sample included in the analysis consisted of 412 responses. The sample is compared to  
457 the population of 57,878 producers growing vine for socio-demographic and farm characteristics



458 in Table 3. 75.24% of respondents are farm owners. The average farm size in the sample is  
459 twice as large as the French viticulture average (many owners of small vine areas use service  
460 providers for technical management of the vineyards, and therefore do not correspond to the  
461 profile sought in our survey), but heterogeneity is very high, both in the population and the  
462 sample (including an outlier of 6,000 ha). 42.2% are members of cooperatives. 26.9% of vine  
463 growers are certified organic farming (17% in the population), 6.1% transitioning to organic  
464 certification and 51.7% have obtained an alternative certification such as High Environmental  
465 Value or Terra Vitis, two environmental certifications, dissociated from but compatible with  
466 organic certification, and giving access similarly to an official label on the marketed products.  
467 These numbers suggest that the sample is more experienced with fungicide reduction than the  
468 population.

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

Table 3: Sample characteristics

Variable	Description	Sample mean	Population
<b>Vine grower's characteristics</b>			
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
<b>Vineyard's characteristics</b>			
Land size (vineyard)	Hectares	45.8	22.1
Ownership of the vineyard	1= Yes, 0 = No	0.752	
<b>Protected indication</b> (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
<b>Collective implication</b>			
Member of a cooperative	1 = Yes, 0 = No	0.422	0.58
Collective score (see Note 2)	between 1 and 5	1.11	
<b>Certification</b> (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%.

## 471 4.2 Adopters' profile

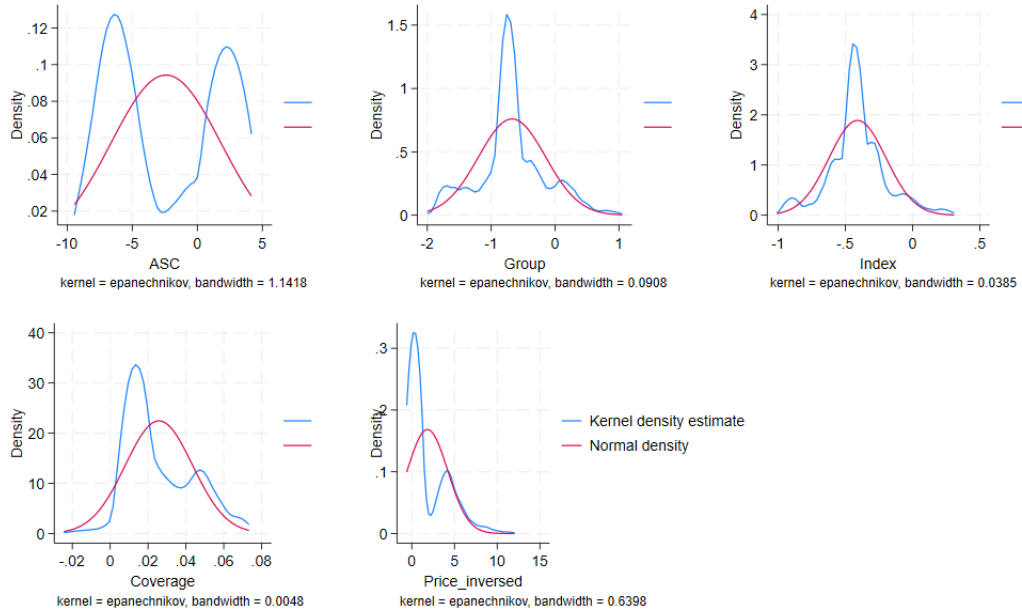
472 While we have a split-sample approach to compare the bonus and penalty framing, our analysis  
473 is performed on the full sample. Indeed, we found that framing has no significant effect on  
474 the number of insurance subscribers, nor on the TFI profile of the subscribers. Producers are  
475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

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

484 **Two classes of adopters.** Figure 2 displays interesting results regarding the distribution  
485 of the individual coefficients in the RPL model. The distribution of individual coefficients for  
486 the ASC and, to a lower extent, price and coverage is bimodal. This suggests that a share  
487 of our sample is more interested by green insurance (negative coefficient for the alternative-  
488 specific constant ASC) and another share is more sensitive to the financial parameters (with high  
489 coefficients for the price and coverage attributes). Latent class estimates in Table 4 confirm that  
490 our sample can be divided into two classes. The number of classes has been chosen to ensure  
491 interpretability, together with maximizing class membership prediction accuracy (Table A.6 in  
492 Appendix F). Class 1 comprises of about 59.5% of the respondents. For class 1, the coefficient  
493 estimates are close to those estimated by the RPL model. Given the negative sign associated with  
494 ASC, growers belonging to class 1 are on average interested by the green insurance. Moreover,  
495 they have a lower price elasticity than class-2 respondents. On the contrary, respondents in  
496 class 2 are not significantly more interested by the insurance than the status-quo, and have

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

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



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

502 Concerning the pest management strategy, we find that transitioning towards organic cer-  
 503 tification has the strongest influence on the probability of belonging to class 1. Organic and  
 504 other certifications also increase the probability of belonging to class 1 compared to having no  
 505 certification, but to a lower extent. Stated willingness to reduce fungicide use in the near future  
 506 (variable *sanitary strategy*) also increases the probability of belonging to class 1.

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

510 probability of belonging to class 1.

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

Table 4: 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

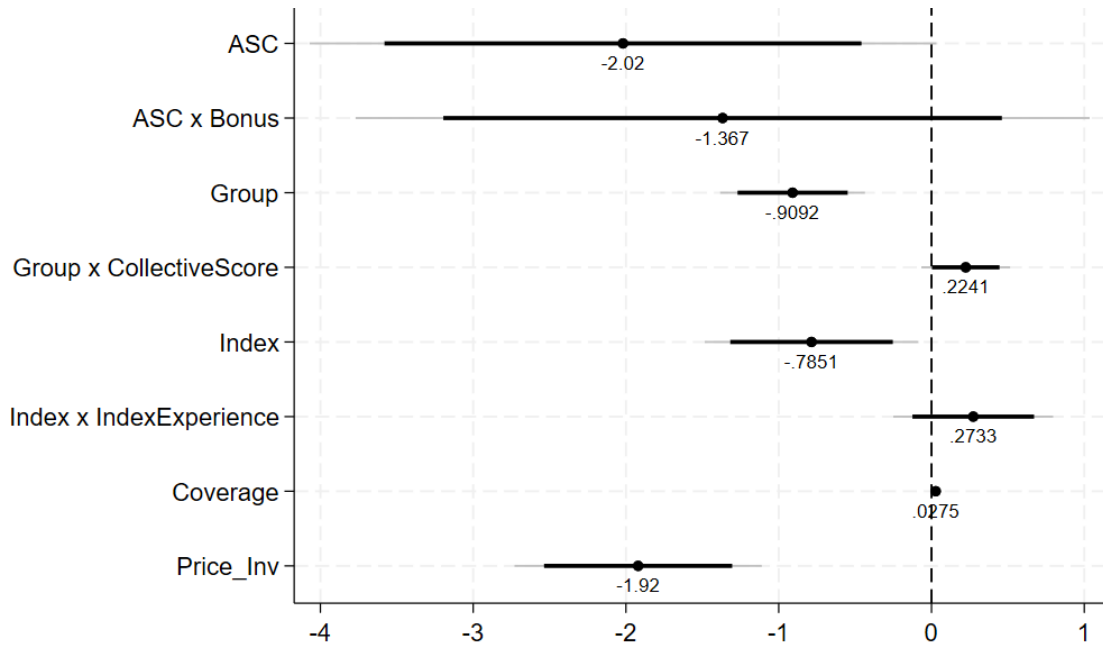
### 513 4.3 Preferences for contract features

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

518 coverage.

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

Figure 3: RPL model: 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.

522 We focus on two sources of heterogeneity with regard to preferences for the Group and Index  
523 attributes. We find that the growers engaged in groups of producers (such as cooperatives where  
524 wine-making or vineyard materials are mutualized, or collective sale points) are less reluctant to  
525 adopt group contracts (variable CollectiveScore). However, we find no evidence that knowledge  
526 or prior experience with index insurance has an influence on preferences for the index-based  
527 contract (variable IndexExperience).

528 We also calculate the adoption rate for different types of green insurance contracts (S1,  
529 S2, and S3 defined in section 3.3.1) (Table 5). In the sample, between 45% and 58% of the

530 vine growers are likely to subscribe to green insurance depending on contract design and prices.  
 531 Adjusting for sampling bias, based on adoption rates such as the one presented in Table 4 for  
 532 contract S1, the adoption rates vary between 48% and 60%.

533 As expected from previous results on preferences for individual and loss-based attributes, the  
 534 adoption rate is higher for scheme S1. Since differences in adoption rates across contract types  
 535 and prices are limited, in the remaining analysis we focus on one contract: the preferred contract  
 536 (S1), in the case of fair insurance (5% price and 50% coverage). This contract is considered fair  
 537 since the loading factor is equal to one when one assumes an expected annual loss of 10%, as  
 538 expected under production with the here selected DSS.<sup>18</sup>

Table 5: Adoption rate by contract type and price (50% coverage)

Contract type Price	S1	S2	S3
	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.

#### 539 4.4 Impact on fungicide use

540 To estimate the potential impact of green insurance on fungicide use in French vineyards, we rely  
 541 on the pesticide use reduction ( $k$ ) that could be obtained thanks to the DSS recommendations  
 542 for those willing to subscribe to insurance<sup>19</sup>. We assume that the incentive constraint is satisfied  
 543 and all subscribing vine growers fully comply with DSS recommendations.<sup>20</sup>

<sup>18</sup>In 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.

<sup>19</sup>Recall that the following estimates focus on the adoption rate of the preferred contract (S1), in the case of fair insurance (5% price and 50% coverage)

<sup>20</sup>After 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

544 Overall, we estimate that adopters in the sample would reduce their fungicide treatment  
545 by 35% on average and a quarter of them can reduce their fungicide treatments by more than  
546 55%. But the average TFI reduction potential hides important heterogeneity: the expected TFI  
547 reduction potential of those willing to subscribe to green insurance ranges from 0 to 84.9%. We  
548 highlight in Table 6 the differences across practices (organic or not), regions and users' relative  
549 position in the region with regard to their TFI. The highest impact is expected for non-organic  
550 producers treating more than the median TFI in low-use regions (-74.70% compared to their  
551 initial TFI on average). The impact is higher in low-use regions since other growers in these  
552 areas have managed to reduce their TFI, which indicates favorable environmental conditions and  
553 lower pest pressure. Extrapolating results to the population, given that 56% of the population  
554 would adopt S1-type green insurance (at a 5% price and 50% coverage), fungicide use could  
555 be reduced by 45% on average at national level (compared to 35% in our sample due to the  
556 over-representation of organic producers, who have on average a lower reduction potential).

Table 6: Average percentage fungicide reduction (with population weight in parenthesis)

<b>Non-organic</b>	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%)
<b>Organic</b>	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%)

Kruskal-Wallis test for difference across cells  $\chi^2(7) = 395.088$ ; Prob = 0.0001

557 We run a sensitivity analysis on the impact of the assumptions on the efficiency of the DSS  
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.



558 to reduce pesticide use on our results (Figure A.4 in Appendix F). To do so, we vary the target  
559 percentile one can reach with the DSS for both types of practices ( $Q_{conventional}; Q_{organic}$ ). We find  
560 that fungicide reduction will be substantial (more than 40%) only if conventional producers using  
561 the DSS can reach TFI levels that are lower than the 5% vine growers treating least intensively.  
562 This is in line with field experimental observations for the DSS, but underlines the importance  
563 of this parameter for results. The overall impact is less dependent on assumptions regarding  
564 the DSS's efficiency for organic producers since the TFI distribution for organic producers is  
565 narrower.

566 We find limited evidence of windfall effects. 23% of the adopters in the sample have a null  
567 expected reduction since their TFI corresponds to TFI\* (63% of them being organic growers).  
568 They would benefit from more secured revenues, partly thanks to the public support of the  
569 bonus, without achieving additional fungicide reduction. Given the For conventional producers,  
570 the proportion of producers with null reduction potential is not significantly different at the  
571 5% level in the adopters and non-adopters groups. For organic producers, the proportion of  
572 producers with null reduction potential is significantly higher in the non-adopters groups. Both  
573 results suggest that the scheme does not particularly attract producers likely to benefit from  
574 windfall effects.

#### 575 **4.5 Cost-efficiency of public support**

576 Adjusting for sampling biais, for an average annual loss of 10%, the program would cost on  
577 average €1457 per hectare and per year. In terms of cost efficiency, the average cost of public  
578 bonus subsidy is €104 per hectare for a 1% reduction in TFI. But we find significant differences  
579 in the cost and cost-efficiency of green insurance subsidies across the eight cells in Table 7.  
580 This heterogeneity is driven by different TFI reduction potential  $k$ , but also differences in the  
581 financial value of insured yields (since the cost of the bonus is proportional to  $\bar{y}$ ). Indeed, the  
582 financial yield is significantly lower in low-use regions (which is driven either by lower yields in  
583 regions such as Côtes du Rhône or lower wine value in regions such as Val de Loire or Gaillac).

584 As a result, the public spending to compensate losses is lower in the low-use regions, compared  
 585 to high-use regions.

Table 7: Average public cost in €/ha for a 1% reduction in TFI (with population weight in parenthesis)

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

Kruskal-Wallis test for differences across cells:  $\chi^2(7) = 75.468$ ; Prob = 0.0001

## 586 4.6 Robustness checks

587 We apply several tests to check the robustness of the results to different specifications (Ap-  
 588 pendix F). We find no significant difference with the estimate for the full sample presented in  
 589 Figure 3 and the estimates for different sub-groups. As a further robustness check, to account  
 590 for inattention bias, we estimated a 3-classes latent class model with all parameters in one class  
 591 restricted to zero (Table A.7 in Appendix F). We find that 40.5% of the respondents were clas-  
 592 sified as making random choices, which is similar to what was found by Malone and Lusk (2018)  
 593 . Estimates for the two other classes remain robust to this specification, but the proportion of  
 594 respondents sensitive to the green insurance attributes (belonging to class 1) is reduced to 25%  
 595 (instead of 40% in Table 4) and we find no significant determinants of class 1 membership.

596 We also tested for overshooting, as defined by Glenck et al. (2023). The criterion compares  
 597 the highest level of the price attribute with the willingness to pay (WTP) for the bundle of  
 598 attributes yielding the highest utility (loss-based individual contract with a 65% coverage rate),  
 599 without including utility captured via alternative specific constant. We find evidence of reason-  
 600 able overshooting: the average WTP for the bundle of attributes yielding the highest utility is  
 601 13.46 (median 2.89). With the highest price level equal to 8, this corresponds to a 68% over-

602 shooting magnitude. As a comparison, over the 305 DCE studies considered by Glenck et al.  
603 (2023), the mean relative magnitude of overshooting is 337%, with a median of 102%.

## 604 5 Discussion

605 **A high pesticide use reduction potential** Our results indicate that green insurance is  
606 an innovative tool that has the potential to induce a shift in practices towards less pesticide  
607 use. More than half of the surveyed French vine growers are interested in green insurance,  
608 in particular if insurance contracts are similar to those offered for current multiple-peril crop  
609 insurance (i.e. individual and loss-based).

610 Producers transitioning to organic grapevine growing are more interested by green insurance  
611 and have a lower price elasticity. A first reason could be that they are already more likely to have  
612 lower yields than their targets (higher  $\rho^0$ ), and are therefore interested in the financial security  
613 offered by the scheme, suggesting some form of adverse selection. They may also be interested in  
614 the technical assistance offered by the DSS to comply with the regulation on maximum copper  
615 use (European Union 2018), reduced from 6 to 4kg/ha in 2018, technically constraining in some  
616 years. However, being already committed and experienced in constrained technical itineraries,  
617 they may also simply have more confidence in their ability to safely decrease fungicide use and  
618 obtain the 30% bonus by following DSS recommendations. In other words, the increase in the  
619 probability of losses due to lower pesticide use ( $\rho^k - \rho^0$ ) appears to be lower for them compared  
620 to other growers, not only because of higher  $\rho^0$  but also because of lower  $\rho^k$ . This could explain  
621 why organic growers with the highest fungicide use in their region (compared to other organic  
622 growers) have the highest adoption rates: observing their neighbours, they can be confident  
623 that they can safely reduce their fungicide use with limited risk on yields. In any case, these  
624 results suggest that green insurance is perceived by growers as a useful tool to support the  
625 transition to organic farming. Green insurance could thus be an interesting complementary  
626 tool to support the political objectives on the up-scaling of organic or pesticide-free production  
627 systems, (Schebesta and Candel 2020; Möhring and Finger 2022), and secure transitions at a

628 time when market signals are currently negative. Beyond the substitution of chemical pesticides  
629 with other crop protection strategies, support for organic farming can also contribute to other  
630 environmental benefits, such as better pest control based on biodiversity (Muneret et al. 2018).

631 The fact that the scheme is particularly attractive to producers transitioning to organic  
632 practices has two consequences: First, it could increase the overall risk to be covered by the in-  
633 surer, as organic growers already face a higher risk. Second, it reduces the overall environmental  
634 performance since the DSS reaches higher TFI reduction for conventional producers. Yet, we  
635 found that producers subscribing to the green insurance scheme can reduce by 45% on average  
636 their treatment frequency index.

637 We observe regional heterogeneity in adoption rates and impact in terms of TFI reduction,  
638 probably driven by the local fungal pressure and wine value. Such results corroborate findings  
639 from the theoretical model on the determinants of the participation constraint. To tailor insur-  
640 ance contracts to different circumstances and increase their attractiveness, insurers will have to  
641 gather sufficient data to correctly price the contracts. This data is not yet available because not  
642 enough growers are making the decision to use very low pesticide levels, and the ones who do  
643 probably have specific characteristics. By inducing a switch to greener practices by a sufficient  
644 share of farmers, subsidized green insurance can generate data on the actual losses incurred over  
645 a few years when using less pesticide. In addition, one may expect the quality of the DSS to  
646 improve thanks to a wider pool of farmers providing feedback on the impact of its recommen-  
647 dations. The development of green insurance can improve the information available to farmers,  
648 insurers, and public authorities.

649 **A gap between producers' preferences and insurers' opinions** Despite high accept-  
650 ability as assessed in the DCE, green insurance is a new product and both the performance of  
651 the DSS and the ability of all insurance subscribers to effectively follow it are still little known.  
652 Providers of green insurance will therefore face contract development costs. Low subscription  
653 rates would further increase transaction costs and delay learning. Our results shed light on  
654 producers' preferences for specific green insurance designs. While the insurers we interviewed

655 believe green insurance should be developed in priority under group and index-based contracts,  
656 we highlight a disinterest in such contracts by most producers.

657 Follow-up questions show that only 2% declared to have already subscribed to an index  
658 insurance and only 27% have already heard about this system before. We could not detect  
659 a significant effect on knowledge and experience with index-insurance on preferences towards  
660 such products to cover fungal disease risk, but the direction of the effect is consistent with  
661 previous work. Farmers' limited understanding of a product is an important factor in their  
662 reduced demand for index insurance (e.g. Cole et al. (2013) and Sibiko et al. (2018) among  
663 others). Extension services and insurers will have to put effort into explaining to farmers how  
664 index insurance works, including the basis risk, often mentioned as the major obstacle (Jensen,  
665 Barrett, and Mude 2016; Jensen, Mude, and Barrett 2018). In the DCE, the basis risk may have  
666 been perceived by respondents as high since we were not very explicit about the specification  
667 of the index. Last but not least, respondents may have not perceived the potential cost-saving  
668 associated with index insurance. It was underlined in the presentation of attributes that in-  
669 dex contracts might reduce transaction costs, and therefore allow insurers to offer significantly  
670 cheaper contracts. But, in the choice cards, it was less explicit since some schemes had both an  
671 index-based evaluation of damages and a higher price (for a higher coverage).

672 Moreover, while French farmers frequently complain about private insurance companies, they  
673 show no interest in group-based contracts, that could be implemented in the form of a mutual  
674 fund, a typically low-cost non-profit organization (Meuwissen, Assefa, and Asseldonk 2013).  
675 Beyond farming, group-based contracts are widely used for risk-sharing. They reduce problems  
676 of asymmetric information and serve as a catalyst for risk prevention and knowledge sharing  
677 (Meuwissen, Bottema, et al. 2019). French vine growers' reluctance could be explained by their  
678 willingness not to engage in contracts with collective commitments, but previous work with  
679 French vine growers has shown that they value collective commitment when it can benefit the  
680 environment (Kuhfuss et al. 2016). In the experiment, we defined the likely perimeter for group  
681 contracts as the cooperative, the perimeter of the indication of origin or the wine region. But at

682 such a scale, fungal disease risk can be systemic and growers may lack trust in the mutual fund's  
683 financial robustness (Giampietri, Yu, and Trestini 2020). Insurance experts generally agree that  
684 pools consisting of less than one-third of a sector cannot sufficiently spread the risks and are too  
685 small to survive (Meuwissen, Assefa, and Asseldonk 2013). Offering index insurance to groups  
686 is foreseen as a promising opportunity to offer insurance products that are both attractive and  
687 easy to implement (Trærup 2012; Santos et al. 2021; Meuwissen, Mey, and Asseldonk 2018).  
688 Indeed, group index-based insurance can be more attractive if a common risk-sharing pool is  
689 set up to transfer excessive payouts, as a remedy to the imperfect correlation between the index  
690 and losses. This system could for example be implemented through cooperatives as follows: an  
691 index-based contract is signed by a cooperative. If the index triggers the indemnity, payment  
692 is made to the cooperative, which then distributes it according to their local understanding  
693 of growers' performance for the year. Loss evaluation is then in the hands of the cooperative,  
694 possibly reducing the cost of insurance and the basis risk perceived by growers.

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

705 **Comparison with other pesticide programs** While green insurance may potentially in-  
706 duce sizable pesticide use reductions, it should be compared with other tools. Based on sample  
707 estimates, the program would cost less than €480 per hectare and per year for half of the  
708 adopters (€1580 on average). This is much more costly than other programs designed to reduce

709 pesticides. In 2018, the DEPHY network, a system of farm advisors implemented on a large  
710 sample of farms in France, cost €150 per hectare and per year (Lapierre, Sauquet, and Julie  
711 2019). The Agri-environmental scheme (AES) payment to reduce herbicides in French vineyards  
712 from 2007 to 2014 ranged from €141 to €350 per hectare and per year. Another AES avail-  
713 able to vine growers close to water catchments from 2014 to 2020 provided incentives to reduce  
714 TFI up to 80% of the local average TFI for a compensation of €301 per hectare and per year  
715 (EAFRD 2014).

716 However, the relatively low cost of these other programs does not imply a high effectiveness.  
717 First, because they attract a very limited number of producers. For example, only around 4,000  
718 hectares out of the 220,000 hectares of vine in the Nouvelle-Aquitaine region (including Bor-  
719 deaux, Cognac, and Bergerac amongst others) have been engaged in an AES targeting herbicide  
720 reduction over the period 2015-2022. Second, participation in the AES does not necessarily in-  
721 fluence management practices. High windfall effects have been reported for some AES schemes  
722 (Chabé-Ferret and Subervie 2013; Ait Sidhoum, Canessa, and Sauer 2023). A public subsidy  
723 to green insurance bonus is more costly per hectare, but it has the potential to attract more  
724 growers and generate more impact in terms of pesticide use reduction. Unfortunately, ex-post  
725 evaluations of adoption rates and impact in terms of TFI reduction of other pesticide programs  
726 are scarce, limiting the possibility of comparing them with the ex-ante evaluation we conducted.  
727 In any case, and whatever the program, the environmental and health benefits associated with  
728 pesticide reduction should also be taken into account in these cost-benefit analyses, such as the  
729 reduction in exposure risk offered by the use of the DSS system (Tago, Andersson, and Treich  
730 2014).

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

735 Other risk management tools than green insurance exist and may better meet some produc-

736 ers' needs. As mentioned by several respondents, the financial risk can be managed by stocking  
737 part of the wine of very productive years, to be included in the blend of the following year, as au-  
738 thorized by European law within the framework of inter-branch organizations (European Union  
739 2013). Inter-annual wine transfers between producers (rather than money transfers through in-  
740 surance indemnity) are preferable when producers fear to loose markets if they have no wine to  
741 sell in a given year. Regarding sanitary risks, an alternative to chemical protection is the adop-  
742 tion of resistant varieties (Finger, Zachmann, and McCallum 2023). This alternative instrument  
743 has not been mentioned by the interviewed growers but is developing rapidly. Further research  
744 is needed to be able to compare the effectiveness and cost-efficiency of short-term solutions such  
745 as reducing pesticide use with green insurance and longer-term ones such as the adoption of  
746 resistant varieties.

747 **Robustness** The robustness of our results relies on the complementary between the theoretical  
748 predictions and the empirical test with the DCE, particularly relevant when predictions are  
749 ambiguous or behavioral factors are coming into play. In particular, we found that high-use  
750 producers, who tend to face adverse conditions or lack expertise needed to reduce fungicide  
751 use, are less likely to subscribe to green insurance, suggesting that their higher cost savings  
752 due to less fungicide use (compared to low-use growers) are not sufficient to counteract the  
753 high perceived risk of losses. The empirical evidence on growers' low interest for index-based  
754 contracts is consistent with the model, if producers overestimate the probability of losses  $\rho^k$   
755 or are pessimistic with regard to the probability of being indemnified  $\rho^i$ . This is likely in the  
756 absence of detailed information in the DCE on the index specification. Furthermore, we predicted  
757 that risk aversion had an ambiguous impact on insurance subscription, especially for index-based  
758 insurance. This is consistent with the absence of influence of self-evaluated risk aversion on green  
759 insurance adoption in the DCE. This confirms the relevance of the risk neutrality assumption  
760 in our model, in particular given that agriculture professionals are known to be less risk-averse  
761 than the general population (Rommel et al. 2023, Vieider et al. 2015).

762 High adoption rates should be taken with a grain of salt given the hypothetical nature of



763 choices in DCEs. Respondents may indeed underestimate the costs of participating in such a  
764 new green insurance scheme, including the transaction costs to enroll in the program, but also  
765 the opportunity cost of time to understand and enact DSS recommendations. Moreover, one  
766 may wonder whether there have been some attributes non attendance. In particular, the small  
767 effect size of the coverage attribute suggests that respondents have focused more on the certain  
768 financial cost of the contract (the premium), and less on the uncertain financial benefit (function  
769 of the coverage level). This may also be due to an anchoring effect to the multi-peril insurance  
770 coverage levels (70%, which corresponds to the lower level of the green insurance). This level  
771 may have been perceived as standard and producers' choices were impacted to a limited extent  
772 by higher coverage rates. Note that given that the framing treatment concerned the coverage  
773 attribute, this may also explain why we found no significant impact of framing. This null result is  
774 nevertheless in line with previous evidence on the limited impact of nudges on farmers (Davidson  
775 and Goodrich 2023, Chabé-Ferret, Le Coent, et al. 2019).

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

## 780 **6 Conclusion**

781 Green insurance could be an important tool for supporting farmers' transition to more envi-  
782 ronmentally friendly production practices, by managing potential economic risks. We provide  
783 evidence of French grapevine growers' interest in a green insurance scheme, coupled with free  
784 access to a Decision Support System, to secure yields while reducing fungicide use. By pro-  
785 viding a secure environment to test reduced pesticide use practices, green insurance coupled  
786 with a DSS can help producers revise their perceptions on the number of treatments needed to  
787 control fungal pressure. Among the 412 surveyed French grapevine growers, 54% are willing to  
788 subscribe to a loss-based individual insurance for an annual price of 5% of the insured capital

789 and an 80% coverage of their losses (including the 30% bonus obtained by complying with DSS  
790 recommendations). Farmers transitioning to organic farming and organic farmers are more likely  
791 to subscribe to green insurance and are less sensitive to insurance price than other producers.  
792 More innovative schemes such as group and index-based contracts are less attractive, despite  
793 having the potential to reduce the costs of green insurance.

794 We also find that publicly subsidized green insurance could provide an innovative policy tool  
795 to reach ambitious pesticide reduction targets. Extrapolating the results to the population level,  
796 we estimate that insured producer would reduce their fungicide treatment by 45% on average,  
797 thanks to DSS recommendations. Having in mind the EU Green Deal target of reducing pesticide  
798 use by 50% by 2030, green insurance could significantly contribute to the objective for the wine  
799 sector.

800 Our results are of direct relevance for policymakers attempting to reform agricultural policy  
801 to achieve an up-to-now elusive reduction in pesticide use, but also to insurers designing new  
802 insurance products to cover disease risks. We believe that they are of relevance beyond the  
803 'tough' context of wine-growing, and beyond France.

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
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## 1044 Appendix

### 1045 Appendix A: Modelling vine growers' decisions

1046 This subsection presents general results for a weakly risk-averse producer (A.1). The case of  
1047 strict risk-aversion is treated here, whereas the main text focuses on the case of risk neutrality.  
1048 This appendix also presents simulations for different values of the bonus  $b$  and the probability  
1049 of loss in case of pesticide use reduction  $\rho_k$  (A.2).

#### 1050 A.1. The model

1051 **Yields and treatments.** We consider a producer with a maximum financial yield  $\bar{y}$  (in  
1052 €/ha). The actual financial yield may be lower due to pest attacks. "Losses" are the difference  
1053 between the maximum yield and the low yield, and are  $l\bar{y}$  where  $l \in [0, 1]$ . They occur with  
1054 probabilities that depend on climatic and geologic conditions but also on treatment intensity.

1055 Each producer has an 'initial' fungicide treatment frequency index  $TFI$ . This is the TFI  
1056 he would choose in the absence of an insurance scheme. We denote  $TFI^*$  the lowest achievable  
1057 treatment level for the targeted yield. We assume that following DSS recommendations, thanks  
1058 to the extensive expertise and information analysis embedded in the tool, allows to reach  $TFI^*$ .  
1059 The corresponding percentage reduction in fungicide is denoted  $k$ . In regions with more fungi  
1060 pressure  $TFI^*$  will remain higher than in regions with lower pressure. To simplify, we assume  
1061 that a producer not following DSS recommendations will not reduce its pesticide use at all.  
1062 Thus,

$$\begin{aligned} k &= \frac{TFI - TFI^*}{TFI} && \text{if DSS recommendations are followed} \\ &= 0 && \text{if DSS recommendations are not followed} \end{aligned}$$

1063 The cost of treatments  $C^k$  increases in the TFI and is therefore lower under DSS recommen-

1064 dations.

$$\begin{aligned} C &= C^k \quad \text{if DSS recommendations are followed} \\ &= C^0 \quad \text{if DSS recommendations are not followed, with } C^0 > C^k. \end{aligned}$$

1065 We denote by  $\rho^k$  the probability of a low yield when the producer commits to reduce fungicide  
1066 by  $k$ .  $\rho^k$  is increasing in  $k$ : producers less experienced with less intensive practices will face more  
1067 losses more frequently.

For a risk-averse producer with a strictly concave utility function  $u(\cdot)$ , expected welfare when following the DSS without insurance, is

$$\mathbf{E}U_k^{No} \equiv (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l)\bar{y}) - C^k.$$

1068 Under risk neutrality, the expression is  $\mathbf{E}U_k^{No} \equiv (1 - \rho^k)\bar{y} + \rho^k(1 - l)\bar{y} - C^k = \bar{y}(1 - \rho^k l) - C^k$ .

1069 In practice in French vineyards, the TFI chosen by producers is widely recognized as too  
1070 high (as discussed in the introduction). Moreover, producers do not choose to use a DSS despite  
1071 its low cost. For instance, the DSS used in the green insurance experimentation run since 2019  
1072 is available at a fixed price of about €250, which is quite small compared to expected cost  
1073 savings of about €200 per hectare for a 50% reduction in TFI. We can therefore assume that  
1074 the following inequality holds, assuming that the cost of the DSS is incorporated in  $C^k$ :

$$\mathbf{E}U_0^{No} \geq \mathbf{E}U_k^{No} \Leftrightarrow (\rho^k - \rho^0)[u(\bar{y}) - u((1 - l)\bar{y})] > C^0 - C^k. \quad (1)$$

1075 The equivalent inequality for risk neutrality is  $(\rho^k - \rho^0)l\bar{y} > C^0 - C^k$ .

1076 The cost savings on fungicides are not enough to compensate for the higher risk of losses  
1077 when reducing one's TFI, even with the help of the DSS.

1078 **The insurance contract.** We denote  $P$  the price of the contract per unit of insured capital  
1079 and  $I$  the indemnity in case of losses. We assume that  $\bar{y}$  is both the maximum yield and the

1080 one insured under the contract. The indemnity  $I$  depends on losses (in the case of loss-based  
 1081 insurance) or the realization of an index (in the case of index-based insurance). The insurance  
 1082 coverage is  $\alpha$  in  $[0,1[$  (meaning there is a deductible of  $1 - \alpha$ ). If the producer follows DSS  
 1083 recommendations he receives an additional bonus indemnity  $b > 0$  in case of yield losses, funded  
 1084 by public authorities. Otherwise, there is no bonus.

$$b > 0 \quad \text{if } k = k^* \text{ (DSS recommendations are followed)}$$

$$b = 0 \quad \text{if } k \neq k^* \text{ (DSS recommendations are not followed)}$$

1085 **The producer's decisions.** The decision to subscribe or not to the insurance (participation)  
 1086 is taken at the start of the grapevine growing season and the decision to comply with the DSS  
 1087 is made afterwards, during the season. We abstract from timing aspects here, but consider the  
 1088 two decisions, that translate into constraints for the insurance scheme to be effective:

- 1089 • Participation constraint ( $PC$ ): The producer prefers to take up the insurance if it provides  
 1090 a higher profit than not reducing their TFI and not benefiting from the contract.
- 1091 • Incentive constraint ( $IC$ ): The producer prefers to take up the insurance and comply with  
 1092 the DSS if it provides a higher profit than taking up the insurance but not reducing her  
 1093 TFI.

1094 The status-quo strategy, with no pesticide use reduction, yields expected profits of  $[(1 -$   
 1095  $\rho^0) + \rho^0(1 - l)]\bar{y} - C^0 = (1 - \rho^0 l)\bar{y} - C^0$ . The participation constraint ( $PC$ ) will be met if the  
 1096 profits obtained when taking up an insurance contract and reducing one's TFI are higher than  
 1097 this expression.

1098 **Loss-based insurance.** With loss-based insurance, the indemnity is perceived if and only if  
 1099  $y = (1 - l)\bar{y}$ , which happens with probability  $\rho^k$ . Indemnity is  $I = (\alpha + b)l\bar{y}$ .

The expected utility for the producer is

$$\mathbf{E}U^L B_k = (1 - \rho^k)u(\bar{y}) + \rho^k u((1 - l(1 - \alpha - b))\bar{y}) - C^k - P$$

1100 under risk-aversion.

1101 Under risk neutrality, expected profits are

$$\mathbf{E}U^L B_k = \bar{y}[1 - \rho^k l(1 - (\alpha + b))] - C^k - P. \quad (2)$$

1102 taking up the contract and following the DSS is profitable if and only if the following participation  
1103 constraint ( $PC$ ) is satisfied:

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

1104 Participation is ensured if the cost savings on pesticides plus the benefit of receiving the indem-  
1105 nity (instead of bearing the full loss) at least compensate for the higher probability of a loss  
1106 (and therefore lower probability of obtaining  $u(\bar{y})$ ) and the premium.

1107 The loss-based insurance contract ensures that the producer is perfectly insured when the  
1108 deductible  $(1 - \alpha)$  is null and the insurance actuarially fair. They also benefit from a reduction  
1109 in cost of crop protection. Moreover, taking up the insurance contract and complying with the  
1110 DSS recommendations is more attractive than taking up the contract without following the DSS



1111 if and only if the following incentive constraint  $(IC)^{LB}$  is satisfied:

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

1112 **Index-based insurance.** The indemnity is triggered by the value of an index, imperfectly  
1113 correlated with realized yields. Such insurance is cheaper than loss-based, and the premium is  
1114  $\beta P$ , with  $\beta \leq 1$ . The producers receive an indemnity with probability  $\rho^i$  (even where the index  
1115 triggers an indemnity). Note that  $\rho^i$  is the same for all producers whose contract depends on  
1116 the same index. The distinct events “suffering losses” and “receiving an indemnity” lead to a  
1117 partition in four states of nature, whose probabilities are given in Table A.1. For instance, with  
1118 probability  $\rho_{l+ni}^k$ , the grapevine grower will suffer losses but no indemnity will be paid.

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

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

1119 For a risk-averse producer, the four states of nature need to be distinguished:

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

1120 And for a risk-neutral producer:

$$\begin{aligned}
\mathbf{E}U_k^{IB} &= (1 - \rho^k)\bar{y} + \rho^k(1 - l)\bar{y} + \rho^i(\alpha + b)l\bar{y} - C^k - \beta P \\
&= \bar{y}(1 - \rho^k l) + \rho^i(\alpha + b)l\bar{y} - C^k - \beta P \\
&= \bar{y}[1 - (\rho^k - \rho^i(\alpha + b))l] - C^k - \beta P
\end{aligned}$$

1121 *Incentives to reduce TFI.* The incentive constraint is satisfied if the profits above are higher  
1122 than the ones obtained when taking up the insurance contract but not reducing one's TFI. This  
1123 strategy provides profits of

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

1124 The incentive constraint that ensures compliance with the DSS thus writes as

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

1125 which can be written as

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

1126 Clearly, beliefs as to the probabilities of the four states, respectively when following the DSS  
1127 and when not reducing one's TFI, are crucial determinants of the decision to reduce fungicide  
1128 use within the insurance contract, together with the bonus  $b$ .

1129 Under risk neutrality, the problem becomes much simpler as one can group profit terms along  
1130 the probabilities of the two events, suffering losses and receiving an indemnity. The value of the  
1131 index is unrelated to the fungicide use of the producer, so that  $\rho_{l+i}^0 + \rho_{nl+i}^0 = \rho_{l+i}^k + \rho_{nl+i}^k = \rho^i$ .

1132 Under risk neutrality, the incentive constraint becomes

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

1133 Since the conditions for the payment of the base indemnity are independent from fungicide use,  
1134 the incentive to reduce one's TFI only depends on the associated cost savings and probabilities  
1135 of yield losses (as without an insurance contract) and the bonus (triggered only in case of

1136 compliance with DSS recommendations). The higher  $b$  and the probability that the index  
 1137 triggers the indemnity,  $\rho^i$ , the more likely it is that the producer will indeed follow the DSS.

1138 *Participation.* The participation constraint states that taking up the insurance contract  
 1139 and following the DSS, is more profitable than foregoing insurance:

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

1140 Participation is obtained if the utility gained in the two states of nature where there is indemni-  
 1141 fication is enough to compensate for the the situations with no indemnity, and for the premium  
 1142 reduced by cost savings.

1143 For a risk-neutral producer, the participation constraints simplifies into

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

1144 Public support through  $b$  or premium subsidy to reduce the premium  $P$  favors insurance  
 1145 subscription, both for index-based and loss-based insurance. Contrary to a subsidy to the  
 1146 premium, a subsidy to the bonus  $b$  also favors complying with the DSS, making the green  
 1147 insurance an effective instrument to reduce fungicide use.

1148 *Preference between loss-based and index-based insurance.* The index-based insurance con-

1149 tract is more attractive to a risk-neutral producer than the loss-based one if and only if

$$\begin{aligned} & \bar{y}[1 - (\rho^k - \rho^i(\alpha + b))l] - C^k - \beta P \\ & \geq \bar{y}[1 - \rho^k l(1 - (\alpha + b))] - C^k - P \\ & \Leftrightarrow (\rho^i - \rho^k)(\alpha + b)l\bar{y} + (1 - \beta)P \geq 0. \end{aligned}$$

## 1150 A.2. Simulation

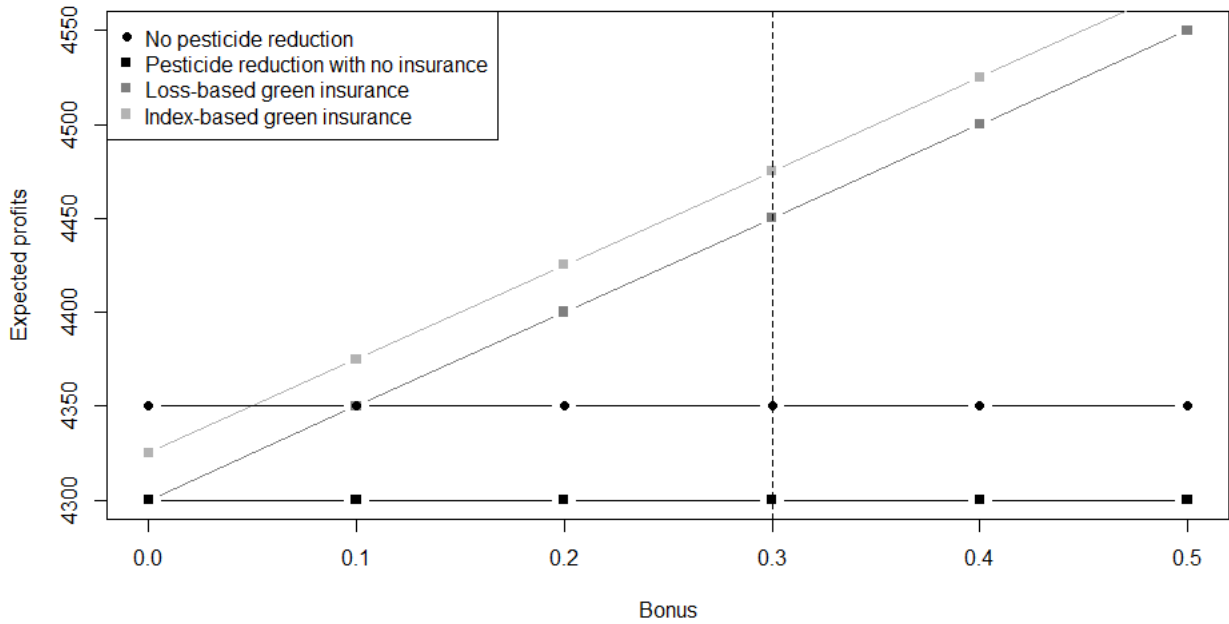
1151 We simulate here the impact on expected profits of (A) one characteristic of the insurance scheme  
1152 not varied in the DCE: the bonus  $b$ ; (B) pesticide efficiency in reducing the risk of catastrophic  
1153 loss  $\rho^0$ , capturing heterogeneity in the fungal disease pressure faced by producers.

1154 We focus on a set-up where producers are always better-off reducing their pesticide use by  
1155 half with insurance than without. We focus on whether they are better off relying on chemical  
1156 protection ( $k = 0$ ) or reducing their pesticide use by half, covered by the green insurance  
1157 ( $k = 0.5$ ).

1158 To do so, we rely on the following assumptions: (1) Producers are risk neutral; (2) The  
1159 probability of loss  $l\rho^k$  when pesticides are reduced by half, and DSS recommendations are  
1160 followed, is calibrated at 10% per year, which corresponds to a catastrophic loss of 100% one  
1161 year out of ten, while the full yield is reached the nine other years ; (3) the probability to be  
1162 indemnified is equal in loss-based and index-based contracts, and producers correctly perceive  
1163 these probabilities ( $\rho^k = \rho^i$ ). Indeed, while no suitable index exists as yet in the context of  
1164 French grapevine growing, insurers would not offer a contract based on an index whose frequency  
1165 was much higher than that of actual losses. And conversely, vine growers would not accept an  
1166 index whose frequency was much lower than that of actual losses; (4) The insured capital  $\bar{y}$   
1167 is equal to €5000/ha (yield of 50 hl/ha and economic value of €100/hl, which corresponds to  
1168 French averages); (5) the cost of treatments  $C^0$  is set at €400/ha, reduced to  $C^k = €200$ /ha  
1169 when pesticides are reduced by half; (6) the price  $P$  of the loss-based contract is set at 5% of  
1170 the insured capital, while the index-based contracts is 10% cheaper (4.5%), for a base coverage

1171 of 50% of losses. In the first simulation (Figure A.1), the bonus is varied from 0 to 50%, such  
 1172 as the total coverage does not exceed 100% of losses. In simulation B, the bonus is set at 30%,  
 1173 as in the DCE. In the second simulation (Figure A.2),  $\rho^0$  is varied from 0 to 0.1, such the  
 1174 loss frequency does not exceed  $\rho^k$ , which is the frequency in the situation where pesticide are  
 1175 reduced. In simulation A,  $\rho^0$  is set at 0.05: all the harvest is lost 1 year out of 20.

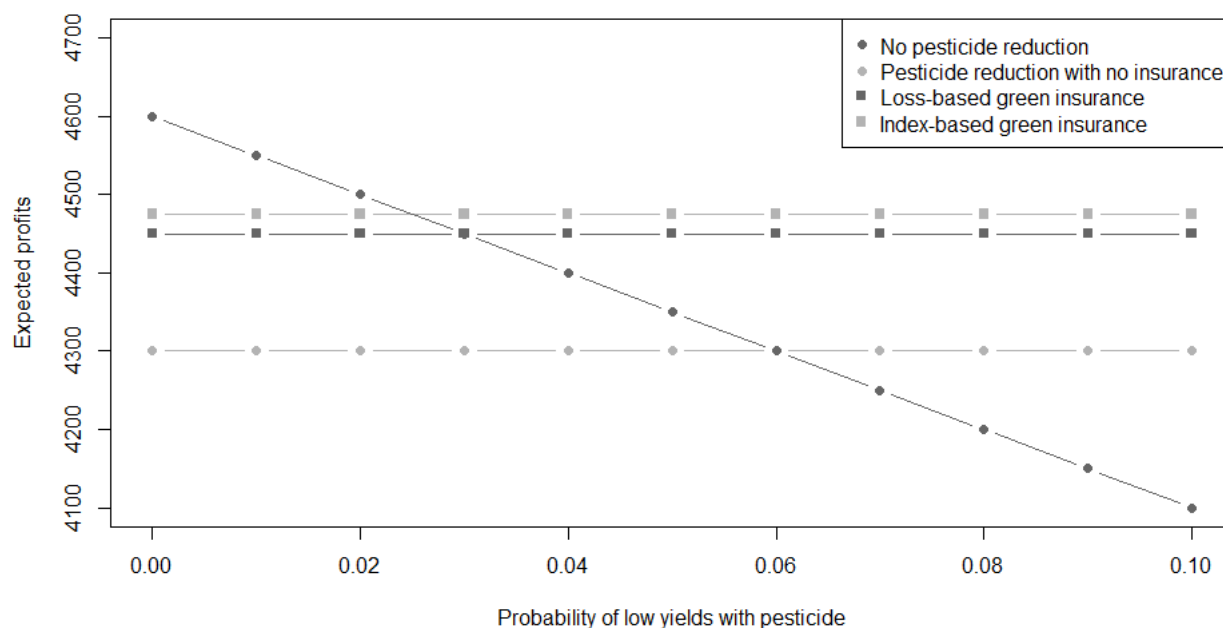
A.1: Impact of bonus on expected profits



Parameters calibration:  $\rho^k = \rho^i = 0.1$ ;  $l = 1$ ;  $\bar{y} = 5000$ ;  $C^0 = 400$ ;  $C^k = 200$ ;  $P = 0.05$ ;  $\beta = 0.9$ ;  $\alpha = 0.5$ ;  $\rho^0 = 0.05$

1176 Figure A.1 shows that in the absence of bonus, producer should stay in the status quo  
 1177 situation without reducing their pesticide use. For a bonus  $b = 5\%$ , reducing pesticide use by  
 1178 half with index-based insurance is more profitable than not reducing pesticide use, while this is  
 1179 the case only for a bonus of  $b = 10\%$  for loss-based insurance, given the higher price.

A.2: Impact of pesticide efficiency in reducing the risk of catastrophic loss  $\rho^0$  on expected profits



Parameters calibration:  $\rho^k = \rho^i = 0.1$ ;  $l = 1$ ;  $\bar{y} = 5000$ ;  $C^0 = 400$ ;  $C^k = 200$ ;  $P = 0.05$ ;  $\beta = 0.9$ ;  $\alpha = 0.5$ ;  $b = 0.3$

1180 Figure A.2 shows that producer should stay in the status quo situation without reducing  
 1181 their pesticide use when the frequency of losing all the harvest with pesticide is lower than  
 1182 one year out of 40 (0.025). When pesticides do not offer full protection and this frequency  $\rho^0$  is  
 1183 higher, reducing pesticide use by half covered by green insurance is more profitable. In this set-  
 1184 up, index-based insurance is always more profitable since it is cheaper for the same probability  
 1185 of receiving an indemnity. If producers perceive the probability of being indemnified to be lower  
 1186 with index-based insurance than loss-based insurance, the opposite result would hold.

1187 With lower capital value ( $\bar{y} < 5000$ ) or more expensive pesticides ( $C^0 > 400$ ), producers  
 1188 could be better off reducing their pesticide without insurance than not reducing their pesticide.  
 1189 Other motivations (risk-aversion, health, environmental concerns,...) may also tilt the balance  
 1190 in favor of reducing treatments. Characteristics of the production context, beyond the fungal

1191 disease pressure as captured by  $\rho^0$ , may also impact the decision to subscribe to the green  
1192 insurance scheme under study. These aspects are better captured in the choice experiment  
1193 where the characteristics of the respondents capture a large diversity of individual situations.



## 1194 **Appendix B: Experts forecasts**

1195 We conducted a prediction survey in autumn and winter 2022. We present here the question-  
1196 naire sent to forecasters and their forecasts. Experts' predictions have been used to formulate  
1197 hypotheses, as advised by Dellavigna et al. (2019).

### 1198 **B.1. Questionnaire sent to forecasters**

1199 We would like your opinion as a professional of the wine sector on the interest that vine growers  
1200 could have for a new insurance scheme. This scheme would allow to mitigate the risks linked to  
1201 fungal diseases in a context of limited use of fungicides. Currently, only the climatic risk (frost,  
1202 hail) is concerned by a subsidized insurance scheme. Your answers are useful for us to guide the  
1203 decisions of public authorities regarding new tools better adapted to the needs of vine growers.

1204 Our team only includes researchers working for public institutions Our study is totally anony-  
1205 mous and is conducted without any commercial or political purpose.

1206 Thank you for your time. [Institutional logos included here]

### 1207 **A. Your Profile**

1208 A1: What is your field of activity?

1209 **If you are a vine grower with no responsibility for representing of the profession,**  
1210 **please do not answer the survey. You will have the chance to respond to the**  
1211 **survey for vine growers during the winter of 2022-2023.**

1212  Production

1213  Wine commercialisation

1214  Consulting (oenology, technical support,...)

1215  Financing (bank, insurance,...)

1216  Research and Development

1217  Other

1218 A2: Can you specify your organization or company?

1219

1220 A3: Do you know the insurable treatment protocol tested by IFV and Groupama on the wine  
1221 cooperatives of Buzet and Tutiac ?

1222  Yes

1223  No

1224 **B. The system considered**

1225 We are talking about a risk management system for fungal diseases. This insurance scheme is  
1226 not available for vine growers. Your opinion will help us to think about the interest and the  
1227 best way to conceive this device.

1228 The scheme provides for:

1229 1. **Financial coverage** for losses due to diseases. The diseases covered are downy mildew,  
1230 powdery mildew, and block rot.

1231 2. A **decision support system** providing treatment recommendations to reduce fungicide  
1232 treatments, formulated by the French Institute of Vine and Wine.

1233 3. A **bonus**, funded by the public authorities, if vine growers follow the protocol's  
1234 recommendations.



1235

1236 **Some details:**

- 1237       • The IFV tool models the development of fungal diseases based on field observations and  
1238       weather data. It advises vine growers on how to carry out fungicide treatments. These  
1239       decision rules have been thought out beforehand with vine growers.
- 1240       • According to the tests over 4 campaigns, following this protocol allows to save,  
1241       depending on the year, between 40 and 70% of fungicides, while still achieving at least  
1242       90% of the yield target.
- 1243       • The scheme is open to all, with or without certification. A specific version of the  
1244       treatment protocol exists for organic farming.
- 1245       • Subscription to this compensation scheme for losses due to disease is independent of the  
1246       multi-risk climate insurance (MRC) which guarantees climatic risks (frost, hail...).
- 1247       • 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**.

1248



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.

1249



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.

1250 B1: In your opinion, what proportion of vine growers would **never** be interested in such a  
1251 guarantee (whatever its characteristics and price)?  % of vine growers.

1252 B2: For which of the two aspects do you think that the vine growers would be interested in the  
1253 device?

1254  Coverage for losses due to fungal diseases.

1255  Treatment protocol to reduce fungicides while maintaining yields.

1256  Other:

1257 *Comment on your choice here:*

1258

1259 B3: The evaluation of the losses can be done:

1260 • **by an expert**, who comes to observe the consequences of the fungal diseases in the  
1261 vineyard plots and then the harvest

1262 • **by an index** of fungal pressure, based on observations of control vines close to of the  
1263 vine growers

1264 In your opinion, what proportion of vine growers would prefer a loss-based evaluation rather  
1265 than an index-based evaluation of losses?

1266  % of vine growers.

1267 B4: Grapevine growers can join the scheme. . .

1268 • **Voluntary** (as for a classic insurance)

1269 • **Compulsory** (as for a mutual fund between vine growers of the same cooperative,  
1270 appellation or wine area)

1271 According to you, what proportion of vine growers would prefer a voluntary membership  
1272 rather than a mandatory one as for a mutual fund?

1273  % of vine growers.

1274 Use the criteria below to draw the profile of the winemaker who:

1275 • In your opinion, is most likely to be interested in this type of tool;

1276 • In your opinion, prefers expertise to the index;

1277 • According to you, prefers voluntary membership to compulsory membership (as for a  
1278 mutual fund between vine growers of the same cooperative, appellation or wine area).

1279 Your answers will be compared to the choices made by vine growers in another survey.

1280 B5: Phyto user profile

1281 *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"/>
1282 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"/>

1283 B6: Certification

1284 *Choose the appropriate answer for each row:*

	HVE	AB	Other certification	No certification	No influence
1285 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"/>

1286 B7: Commercialisation

1287 *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"/>
1288 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"/>

1289 B8: Diversification

1290 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"/>
1291 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"/>

1292 B9: Production mainly in...

1293 Choose the appropriate answer for each row:



1294

	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"/>

1295 B10: Using Decision Support System

1296 *Choose the appropriate answer for each row:*

1297

	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"/>

1298 B11: Insurance

1299 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
1300 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"/>

1301 B12: Responsibility

1302 Choose the appropriate answer for each row:

	Owner	Manager	No influence
1303 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"/>

1304 B13: Production value

1305 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
1306 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"/>

1307 C. What parameters?

1308 We would like to know your opinion on the parameters that could make the system attractive  
1309 to vine growers.

1310 C1: According to you, what minimum coverage and maximum price should be offered to vine  
1311 growers to make the insurance scheme attractive?

1312 Coverage (in % of assessed loss)

1313

1314 Premium (in % of the insured capital)

1315

1316 C2: According to you, what difference in coverage should be applied between a grower who  
1317 follows exactly the treatment protocol and one who treats more during a campaign?

1318  % of losses

1319 C3: Do you think that vine growers would be more interested in an insurance scheme...

1320  with a compensation of 90-(Bonus)%, completed by a bonus of (Bonus)% if they follow  
1321 the treatment protocol

1322  with a compensation of 90%, reduced by (Bonus)% if the treatment protocol is not  
1323 followed

1324  This has no influence.

1325 C4: Do you think that vine growers would be more willing to follow exactly the treatment  
1326 protocol under an insurance scheme

1327  with a compensation of 90-(Bonus)%, completed by a bonus of (Bonus)% if they follow  
1328 the treatment protocol

1329  with a compensation of 90%, reduced by (Bonus)% if the treatment protocol is not  
1330 followed

1331  This has no influence.

1332 **D. About you**

1333 D1: How long have you been working in the wine sector?

1334 *Your answer must be between 1940 and 2022.*

1335 D3: In which area do you work (department number)?

1336 **E. To thank you for your participation**

1337 E1: Would you like to participate to a random draw for the first 50 people who completed the  
1338 entire survey? To be won: Six bottles of Crémant de Loire made for the 50th anniversary of  
1339 the University.

1340  Yes

1341  No

1342 E2: Please enter your email, the winner will receive an e-mail asking her to indicate her postal  
1343 address to receive the bottles at home.

1344 E3: Would you like to receive the results of the study by email in 2023?

1345  Yes

1346  No

1347 E4: Please enter your email address to receive the results

1348

1349 **F. Comments**

1350 F1: Thank you for your answers. They will be compared to the choices made by vine growers  
1351 in another survey. You can indicate here any reaction or suggestion related to this  
1352 questionnaire.

1353

1354 Thank you for your time in answering this questionnaire.

1355 If you have any comments, please do not hesitate to contact us: [email address provided]

1356 Thank you for completing this questionnaire.

## 1357 **B.2. Forecast results**

1358 We summarize here experts' forecasts on vine growers' preferences collected with the prediction  
1359 survey. While the prediction survey included more questions, we focus here on the forecasts  
1360 related to the pre-registered hypotheses.

1361 Experts anticipate more interest for green insurance from vine growers treating less than the  
1362 average. → Pre-registered hypothesis H3

1363 Concerning the impact of producers and farms' characteristics, most experts forecast that  
1364 vine growers already committed to and satisfied with a climatic insurance, would be interested  
1365 by green insurance. → Pre-registered hypothesis H2

1366 According to the expert's estimates, 71% of vine growers would prefer a voluntary individual  
1367 contract rather than a mandatory group one. → Pre-registered hypothesis H5

1368 On average the experts believe that 64% of vine growers would rather prefer an expert-based  
1369 insurance than an index-based insurance. → Pre-registered hypothesis H6

1370 Most experts predict that vine growers would be more interested by the green insurance  
1371 with the bonus framing, but have ambiguous forecasts concerning the impact of framing on  
1372 compliance with DSS recommendations. → Pre-registered hypothesis H7

## 1373 **Appendix C: Pre-registered hypotheses**

1374 The following hypotheses are based on the literature on pesticide use reduction and Agri-  
1375 Environmental Scheme and insurance contract choices. They are also in-line with results from  
1376 a prediction survey conducted in autumn and winter 2022 to collect experts' forecasts on vine  
1377 growers' preferences for the different attributes, and impacts of farm and producers' character-  
1378 istics on these preferences.

1379 H1: Grapevine growers have a positive willingness to pay for such a green insurance covering  
1380 yield losses due to fungal diseases.

1381 H2: Risk and producers risk preferences will both influence producers willingness to adopt  
1382 green insurance and to follow DSS recommendations to reduce their fungicide use.

1383 H3: Self-selection into the scheme: H3a: Grapevine growers who are treating intensively will  
1384 be (despite characteristics that make them treat more) attracted by the technical and financial  
1385 assistance provided by the scheme, because this group likely includes the most risk-averse vine  
1386 growers. H3b: Grapevine growers who are treating less intensively will be the most attracted  
1387 by the scheme, as they are more likely to receive the bonus and get windfall benefits.

1388 H4: Grapevine growers are more willing to pay for a green insurance contract with better  
1389 coverage (lower deductible) and lower premium.

1390 H5: Vne growers are less willing to pay for a collective contract, but this effect is reduced  
1391 for vine growers who are already working together, especially those members of a cooperative.

1392 H6: Grapevine growers are less willing to pay for an index insurance, but this effect is  
1393 reduced for those who have already experienced such insurance and those more innovation-  
1394 oriented (proxied by producers' characteristics).

1395 H7: Grapevine growers are more willing to pay for green insurance in the bonus framing,  
1396 but are less likely to comply with DSS recommendations, compared to the penalty framing.

1397 H8: Green insurance is an effective instrument to achieve fungicide reductions in line with  
1398 targets of the French National Action Plan (Ecophyto) and the EU green deal.

1399 **Appendix D: Framing effect - Results**

1400 To test for the impact of framing on preferences towards green insurance, we estimate the RPL  
 1401 model for the bonus and penalty framing sub-samples separately. The hypothesis that we have  
 1402 significant effects in presenting the indemnity as a bonus or penalty is verified by the means of a  
 1403 likelihood ratio (LR) test (Höhler and Schreiner 2019 ; Contini et al. 2019). The value of the LR  
 1404  $(-2(-1276.68-(-724.825-516.79)))$  test is lower than the critical value for  $\chi^2$  statistic at 5% with  
 1405 10 degree of freedom (18.307). We can therefore not reject the null hypothesis. This indicates  
 1406 that presenting the indemnity as a bonus or penalty does not significantly change respondents'  
 1407 preferences, even when the scale differences between treatments are controlled for.

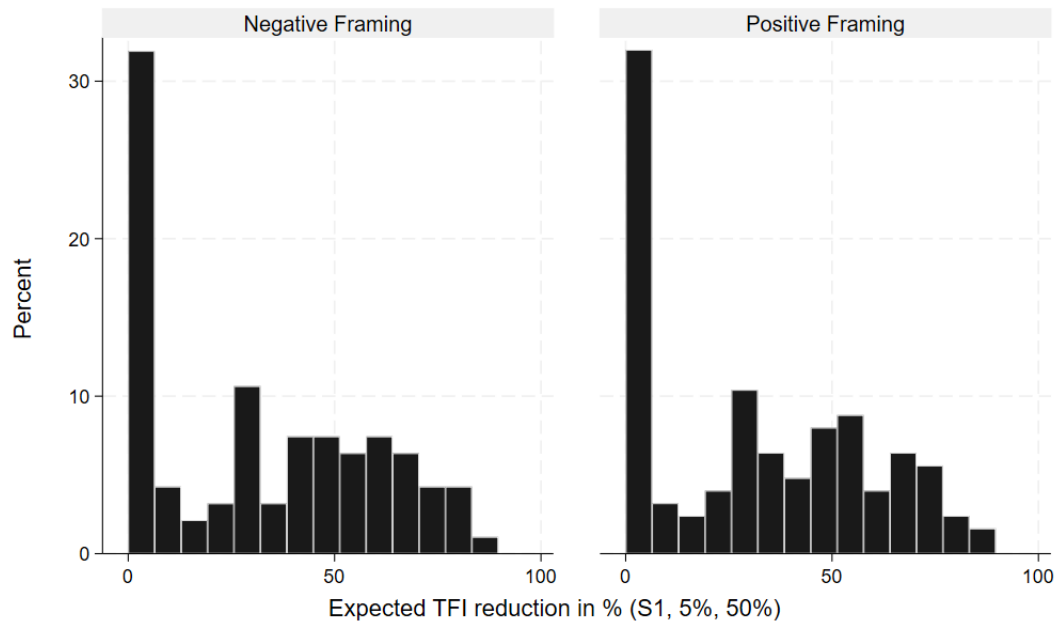
1408 Moreover, we verified that the framing has no selection impact: producers subscribing to  
 1409 insurance in the bonus framing group are not significantly different from those in the penalty  
 1410 framing group in terms of TFI reduction potentials (Figure A.3), according to the Kruskal–Wallis  
 1411 equality-of-populations rank test ( $\chi^2(1) = 0.057$ ; Prob = 0.8112)

A.2: 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.3: 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



## 1412 **Appendix E: Adoption rate by regions**

1413 We observe in Table A.3 that there are less adopters in regions where wine value is higher (Côte-  
1414 du-Rhône Nord, Charentes, Champagne, Bourgogne) or disease pressure is lower (Languedoc,  
1415 Provence). When the production value is high, the uninsured part of losses  $(1 - \alpha - b)l\bar{y}$  dampens  
1416 the incentive to get the green insurance. Where the risk of losses is lower, the premium  $P$  appears  
1417 too costly and the cost savings from following the DSS are limited (low  $C^0 - C^k$ ). In both  
1418 cases, the participation constraint ( $PC$ ) is less likely to be satisfied. Nevertheless, due to the  
1419 interplay of different regional characteristics, there is no significant difference in the adoption  
1420 rate between the regions where regional average TFI is below the national median (Low-use  
1421 regions) compared to the other regions (High-use regions). Organic growers (including those  
1422 in transition) are particularly likely to subscribe to green insurance if their are high users in  
1423 high-use regions (Table A. 4).

A.3: Respondents and adopters by region

<b>Region</b>	<b>Low use/High use+</b>	<b>Adopter*</b>	<b>Sample</b>	<b>Population**</b>
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.4: Adoption rates of the S1 contract (5% price and 50% coverage)(with population weight in parenthesis)

<b>Non-organic</b>	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%)
<b>Organic</b>	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

## 1424 **Appendix F: Robustness checks**

1425 We run the same RPL model than the one presented in the main text (Figure 2) to different  
1426 subgroups. In column (1), we first exclude responses to the first choice card seen by respondents,  
1427 to account for learning effects. In column (2), we exclude responses to the last choice card in order  
1428 to check for a lassitude effect. In column (3), we exclude respondents who indicated no interest  
1429 in the scheme before answering choice cards, since they are more likely to have provided random  
1430 answers. In column (4), we exclude those who have always opted-out. Finally, in column (5), we  
1431 exclude respondents who read the description of attributes, including the video presenting the  
1432 DSS, in less than thirty seconds, which is considered as too short for a comprehensive overview of  
1433 the green insurance scheme. In column (6), we exclude the 36 respondents who were interviewed  
1434 face to face in order to keep only self-completed responses.

A.5: RPL estimates for subgroups

Model	(1)Excl first choice (Learning effects)	(2)Excl last choice (Lassitude effect)	(3)Excl. not inter- ested	(4)Excl. always opt- 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)	1.138*** (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

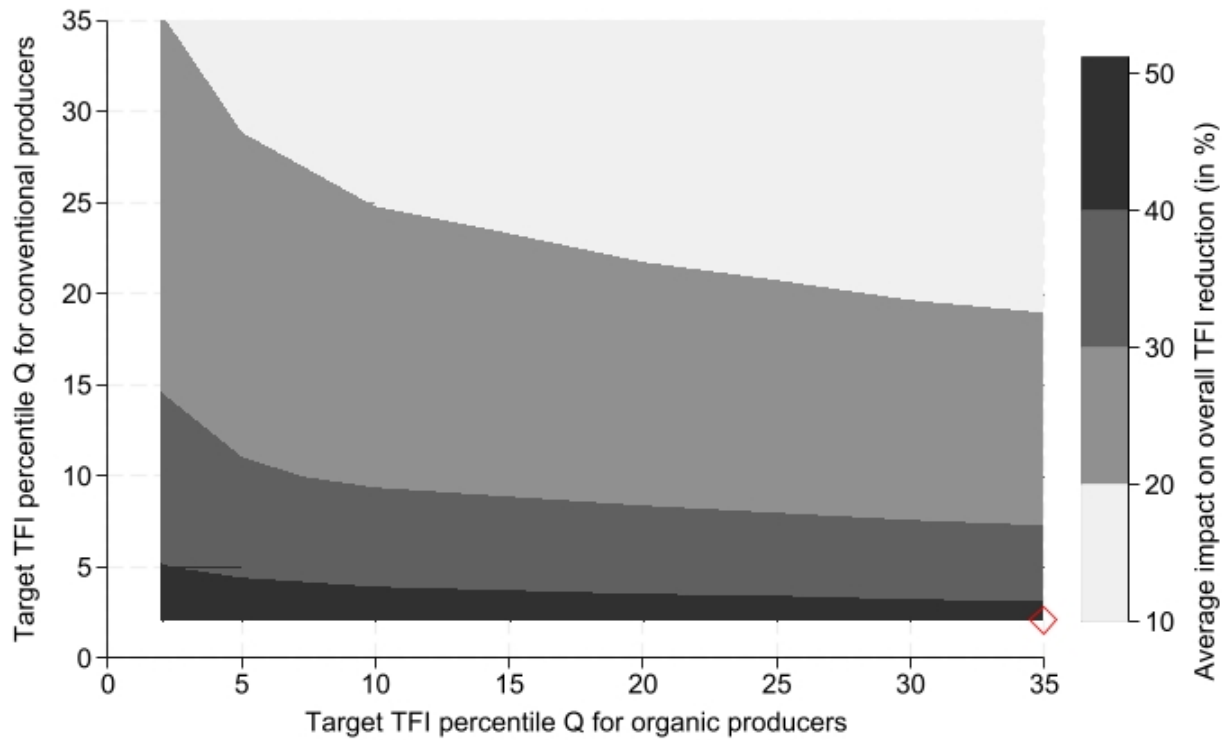
t statistics in parentheses : \*  $p < 0.10$ , \*\*  $p < 0.05$ , \*\*\*  $p < 0.01$

A.6: 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
<b>2</b>	-1294.102	2618.203	2678.52	<b>98.24%</b>
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.

A.4: Sensitivity analysis: Impact of green insurance on TFI reduction at the population level, according to DSS environmental 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.

A.7: 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

## A.8: Channels used for survey dissemination

<b>Chanel</b>	<b>Targeted population</b>
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	



1436 **Appendix H: English version of the vine grower survey**

1437 We are looking for your point of view on new tools, designed to help you compensate the risks  
1438 associated with fungal diseases.

1439 Currently, only the climatic risk (frost, hail) can benefit from a subsidized system. However,  
1440 the risks of losses associated with diseases also prevail for the wine sector, even more in a context  
1441 of reduction of phytosanitary products use.

1442 By responding to this study today, you are helping to guide the decisions of public authorities  
1443 to design and implement new tools better adapted to the needs of vine growers.

1444 Our team includes only researchers working for public institutions. Our study, totally anony-  
1445 mous and validated by an ethics committee, is conducted without commercial or political pur-  
1446 poses.

1447 Thank you for your time.

1448 This project is funded by: [institutional logos included]

1449 **INTRODUCTION**

1450 *Expected answers*

1451 We are expecting answers from people in charge of financial decisions in a vineyard, but also  
1452 in charge of decisions related to phytosanitary treatments. Do not hesitate to answer as a duo  
1453 with the financial manager and the technical manager.

1454 You will need to provide your Fungicide Treatment Frequency Index (TFI) for the last three  
1455 years (it will not be disclosed). You will then be able to compare it with regional averages.

1456 Please have this information ready before you start. If you do not already have access to  
1457 TFI, you can calculate it [here](#). To get your Fungicide TFI from this calculator, enter only your  
1458 fungicide treatments. The first value in the table (1<sup>st</sup> line "TFI") is your fungicide TFI.

1459 *Data management*

1460 This study is anonymous. Neither your name nor your company's name will be asked.  
1461 In accordance with the principles of open science, and in compliance with the General Data  
1462 Protection Regulation, data will be anonymized before archiving and made available for scientific

1463 use.

1464 ***Duration***

1465 The survey takes about 12 minutes. You can stop at any time and return to the questionnaire  
1466 later, by clicking on the same link. To return to the questions on the previous page, click on  
1467 "previous" at the bottom left of each page but do not go back on the navigator, otherwise your  
1468 answers will not be saved.

1469 ***Contact***

1470 For any question : [contact email provided]

1471 B1: Consent

1472  I confirm that I have read and understood the above information. I am at least 18 years  
1473 old and I give my consent to participate in this study.

1474  I do not give my consent.

1475 *(The survey ends here if the answer is "I do not give my consent.")*

1476 **Filters**

1477 C1: Are you responsible for the financial management decisions of a vineyard ?

1478  Yes

1479  No

1480 *(The survey ends here if the answer is "No")*

1481 C2: Are you in charge of decisions regarding vineyard management, including treatments?

1482  Yes, I am responsible for vineyard treatments.

1483  Yes, I participate in the reflections on the treatments of the vineyard.

1484  No, someone else is in charge and I am not consulted.

1485 *(The survey ends here if the answer is "No, someone else is in charge and I am not*  
1486 *consulted.")*

1487 C3: What is your role in the vineyard ?

1488  Owner

1489  Manager (employee)

1490  Other :

1491 C4: How long have you been working in viticulture ?

1492 *If you have been working in viticulture for less than one year, put 0.*

1493  Years

1494 **Profile of the vineyard**

1495 D1: In which grapevine-growing area is your vineyard located (or most of it if it is located in  
1496 several regions)?

1497  Alsace

1498  Beaujolais

1499  Bordelais

1500  Bouches-du-Rhône

1501  Bourgogne

1502  Bugey-Savoie

1503  Cahors

1504  Champagne

1505  Charentes

- 1506  Cher
- 1507  Corse
- 1508  Côtes-du-Rhône Nord (northern part of the departments 07 and 26)
- 1509  Côtes-du-Rhône Sud (southern part of the departments 07 and 26)
- 1510  Dordogne
- 1511  Gaillac
- 1512  Gers
- 1513  Jura
- 1514  Languedoc hors Pyrénées-Orientales
- 1515  Lot-et-Garonne
- 1516  Provence (Var-Vaucluse)
- 1517  Pyrénées Orientales
- 1518  Val de Loire
- 1519 D2: Are the products from your vineyards commercialized under one or more of these
- 1520 designations?
- 1521  Protected denomination of origin (AOP/AOC)
- 1522  Protected geographic indication (IGP)
- 1523  Without indication (e.g. Vin de France or Vin de la Communauté Européenne)
- 1524 D3: What is the size of your vineyard ?
- 1525 *Only numbers are accepted*

1526 Surface dedicated to wine grape production  (ha)

1527 Surface dedicated to other productions  (ha)

1528 D4: What is your dominant commercialization mode ?

1529  Grape

1530  Bulk

1531  Bottle

1532  Mixed (specify in the comment area)

1533

--

1534 D5: Are you in one or more of these situations ?

1535  Member of a cooperative

1536  Member of a CUMA

1537  Member of a GIEE

1538  Member of a collective sales outlet

1539  Elected official/vine grower representative

1540 **Phytosanitary strategy**

1541 E1: Concerning the management of vine diseases, for example to test new protection practices,

1542 how would you position yourself between very careful and risk-taking?

1543

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"/>

1544 E2: Does your vineyard or wine production follow one or more of these specifications?

- 1545  Certified High Environmental Value (Level 3)
- 1546  Certified Organic Agriculture
- 1547  Certified Demeter or Biodyvin
- 1548  Certified Terra Vitis
- 1549  My vineyard was certified OA but is no longer certified
- 1550  In conversion towards Organic Agriculture
- 1551  None
- 1552  Other :

1553 E3: Do you know your Fungicide TFI for 2020, 2021 and 2022?

1554 *Reminder: If you do not already have access to it, you can calculate it here [link provided]. To*  
 1555 *get the fungicide TFI from this calculator, please fill in only your fungicide treatments. The 1<sup>st</sup>*  
 1556 *value of the table obtained (1<sup>st</sup> line "TFI") will then be your fungicide TFI.*

1557  Yes

1558  No

1559 Over the last 3 years, what has been the fungicide TFI (including copper) of your vineyard?

1560 Please also count the fungicides authorized in Organic Agriculture such as copper.

1561 [if E3 == Yes]

		Fungicide TFI
1562	E4:	2020
	E5:	2021
	E6:	2022

1563 [if E3 == No]

1564 E7: Can you at least tell us the number of fungicide applications (including copper)?

1565	2020	
	2021	
	2022	

1566 E8: Considering the specificities of your farm, how would you rate your use of fungicides  
1567 compared to other vine growers in your area?

1568  You think that your use is much lower than that of others.

1569  You think your use is slightly lower than others.

1570  You think your use is about average.

1571  You think your usage is slightly higher than others.

1572  You think your usage is much higher than others.

1573 E9: Was your farm engaged in a AECM contract (Agri-Environmental and Climatic Measure  
1574 of the CAP) with a commitment to reduce the Treatment Frequency Index over at least part  
1575 of the period 2015-2022?

1576  Yes

1577  No

1578 E10: What is your current state of mind regarding your plant protection strategy?

1579  For the moment, reducing my use of fungicides is not my priority.

1580  I have already reduced my use of fungicides, it is difficult to go further.

1581  I am trying to reduce my use of fungicides, but I find it complicated.

1582      I am in the process of reducing my fungicide use.

1583 E11: Do you currently use a decision support system (DSS) to adjust your phytosanitary  
1584 treatments ?

1585 *By the term DSS, we are talking about the different digital tools offered to vine growers today,*  
1586 *from various organizations (agriculture chambers, technical institutes, private companies), to*  
1587 *advise you in the adjustment of phytosanitary treatments.*

1588      Yes and I am satisfied

1589      Yes and it is not very satisfactory

1590      No, not for now but I am thinking about it

1591      No, I don't use it and I'm not interested in it

1592 **The insurance scheme**

1593 We would like to know your opinion on an insurance scheme, still in reflection, for managing  
1594 the risks associated with fungal diseases.

1595 *[The participants were assigned randomly to questions on the scheme in the bonus **or** the*  
1596 *penalty framing. Hereafter will be displayed the presentation of both bonus and penalty framing*  
1597 *but the participants only read the parts they were assigned to.]*

1598 [BONUS framing] **The insurance scheme provides:**

1599     1. **Financial coverage** for annual losses due to diseases. The diseases concerned are downy  
1600         mildew, powdery mildew and black rot.

1601     2. The provision of a **treatment protocol** formulated by the IFV (French Institute of  
1602         Vine and Wine) to reduce fungicide treatments as safely as possible.

1603     3. A **financial bonus**, financed by the public authorities, if the vine growers follow the  
1604         recommendations of the protocol.



1605 [PENALTY framing] **The insurance scheme provides:**

1606 1. **Financial coverage** co-funded by public authorities for annual losses due to diseases.

1607 The diseases concerned are downy mildew, powdery mildew and black rot.

1608 2. The provision of a **treatment protocol** formulated by the IFV (French Institute of

1609 Vine and Wine) to reduce fungicide treatments as safely as possible.

1610 3. If vine growers prefer not to follow the DSS recommendations, and use more fungicides, a

1611 **penalty** applies such that the **coverage is lowered** (no co-funding by public

1612 authorities in this case).

1613 Access to the insurance scheme is subject to the payment of a fee. The subscription is

1614 necessarily made for the whole of a vineyard. The access to the decision support system

1615 communicating the treatment protocol is included in the subscription fee.

1616 You can view the testimony of a vine grower who has experienced this insurance scheme as

1617 part of the VitiREV project in New Aquitaine (Right click on the image).



1618

1619 The video is also available [here](#)

1620 Some details:

1621 - The insurance scheme adoption is open to all, with or without certification. A specific

1622 version of the treatment protocol exists for vineyards in organic agriculture.

1623 - The practices of the vine growers can be controlled (treatment notebooks, visits).

1624 - Subscription to this insurance scheme for losses due to diseases is independent of the  
1625 multi-risk climate insurance (MRC). You may wish to subscribe to one or the other, or  
1626 both but with no obligation.

### 1627 **Insurance scheme versions**

1628 From the general insurance scheme presented above, several versions can be considered.

1629 Your opinion will allow us to think about the interest and the best way to conceive this  
1630 insurance scheme if it is one day proposed to the vine growers.

1631 Here are the possibilities considered:

1632 **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).

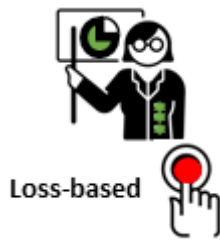
1633

#### **Collective**



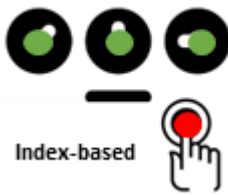
The vine growers subscribe to a **group** contract, for example within the framework of a mutual fund between vine growers of the same cooperative, appellation or wine basin. In this case, membership is compulsory for all the vine growers in the group concerned.

1634 **DAMAGE EVALUATION:**



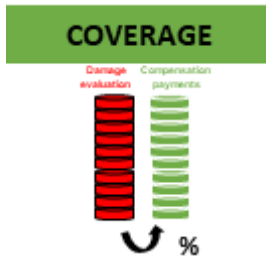
1635

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.

1636 **COVERAGE:**

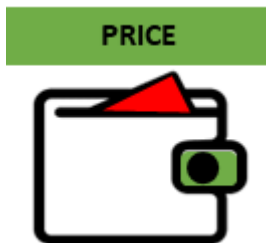


1637

[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.

1638 **PREMIUM:**



1639

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.

1640

1641 **Simulation**

1642 Let's simulate the case of your vineyard.

1643 Imagine that you want to sign up for this insurance scheme, please indicate below the pa-  
1644 rameters you would choose to view the compensation amounts at the bottom of the page.

1645 If you have several values in mind, please give us the one for your main production.

1646 H1: On average over the last 5 years, at what price do you value your production (in €per  
1647 hectoliter of wine)?

1648 *We need this information to provide you with compensation amounts that are appropriate*  
1649 *for your situation. If you do not know or do not wish to give an exact amount, please give an*  
1650 *estimate.*

1651  (€/hL)

1652 H2: What level of return do you want to ensure ?

1653 *You can set it to your potential return. The only constraint is that this level has been reached*  
1654 *at least once in the last 5 years.*

1655  (€/hL)

1656 H3: The following table shows you the level of compensation you would receive under this  
1657 insurance scheme for an amount of losses of 10% due to fungal disease.

1658 *As a reminder, following this DSS treatment protocol associated with the device allows to*  
1659 *save, depending on the year, between 40 and 70% of fungicides, while allowing to reach at least*  
1660 *90% of the yield objective. Losses will therefore rarely exceed 10%.*

1661 [BONUS FRAMING] Estimation of the compensation for **YOUR** vineyard:

1662

	<b>COVERAGE</b>	<b>COVERAGE</b>
Coverage rate		
<b>Basis coverage</b> in €/ha	_____€/ha (40%)	_____€/ha (65%)
Coverage with the <b>bonus</b> of 30% in €/ha	_____€/ha (70%)	_____€/ha (95%)

1663

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

1664

	<b>COVERAGE</b>	<b>COVERAGE</b>
Coverage rate		
<b>Basis coverage</b> in €/ha	_____€/ha (70%)	_____€/ha (95%)
Coverage with the <b>penalty</b> of 30% in €/ha	_____€/ha (40%)	_____€/ha (65%)

1665

H4: What do you think?

1666

I might be interested in this device, depending on how it is set up and its price.

1667

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.

1668

1669

*[For the 4 following choices, the cards are displayed here in the bonus framing only but*

1670

*participants to the survey were assigned to bonus or penalty and saw the corresponding choice*

1671

*cards]*

1672

**Choice 1/4**

1673

On each of the following 4 pages, you will see two insurance schemes with different charac-








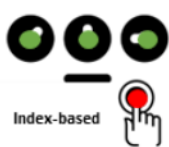








1674

teristics (Scheme A and Scheme B, shown below in columns).

1675 Even if these schemes do not exist for now, please choose between the two schemes the one  
1676 you would prefer for YOUR vineyard, as you would do in reality if these schemes were offered to  
1677 you. It is like choosing between two menus in a restaurant: Drink/Entry/Main Course/Dessert,  
1678 without being able to choose each menu item separately. If you are not interested in any of the  
1679 proposed features, you can choose "No Guarantee".

1680 There is no right or wrong answer. Keep in mind the situation of YOUR vineyard. This is  
1681 what will allow us to more reliably assess what is best for each individual situation.

1682 You can review what each pictogram means by clicking on (i). This opens a new information  
1683 tab that you must close to return to the questionnaire.

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

1684









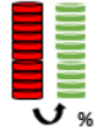

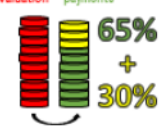
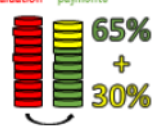




1685

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

1686 **Choice 2/4**

1687 You have to make a choice again. You do not have to worry about your previous choice  
1688 to choose on this page because the scheme presented are different. You can review what each  
1689 pictogram means by clicking on (i).



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

1690









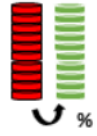



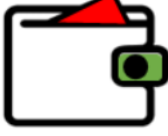



1691

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

1692 **Choice 3/4**

1693 You have to make a choice again. You may find this a bit long but we need your choice on

1694 several possible configurations of the scheme. Thank you.

	A	B
<b>TYPE OF CONTRACT</b>  	<b>Collective</b> 	<b>Individual</b> 
<b>DAMAGE EVALUATION</b>  	 Index-based	 Loss-based
<b>COVERAGE</b>  	 55% + 30%	 40% + 30%
<b>PRICE</b>  	 5% of insured capital	 3% of insured capital
For your vineyard	(Average yield* Value* 0.05 ) €/ha	(Average yield* Value * 0.03) €/ha








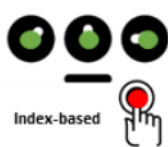








1695

1696

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

1697 **Choice 4/4**

1698 Thank you for choosing again. This is the last one

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

1699

1700

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

1701 **To better understand your choices**

1702 You have almost finished, thank you! A few last questions to help us to understand your  
1703 choices and your situation.

1704 M2: What are the reasons you chose not to purchase any of the guarantees presented? [Only

1705 for respondents who always choose no guarantee]

1706 You may choose up to 3 reasons and rank them in order of importance.

1707  I have few fungal diseases in my vineyards

1708  I am not interested in reducing my use of fungicides

1709  I manage my phytosanitary risk myself without needing anyone else

1710  I have organized my activity to support a financial loss one year (Individual Complementary Volume, diversification, provision...)

1712  I do not trust that I will be correctly compensated in case of losses

1713  I do not see the interest because I already have a multi-risk climate insurance

1714  I imagine very heavy administrative procedures

1715  The price is too high

1716  Other (please specify in the next question)

1717 M3: Please specify for what other reason you have chosen not to purchase any of the guarantees presented.

1719

1720 M4: The insurance scheme has been designed to give you flexibility in following the DSS recommendations.

1722 [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.

1725 [PENALTY] Reminder: If you follow the DSS recommendations (dates, doses) and do not  
1726 perform any treatments other than those recommended by the protocol, you would receive the  
1727 maximal coverage. However, if you do not follow the DSS recommendations, a penalty would  
1728 lower the coverage and you would receive 30% less than the maximal coverage.

1729 If you had the opportunity to actually subscribe to this tool, how would you use the DSS  
1730 recommendations?

1731 [BONUS]

1732  Not following the DSS recommendations at the beginning of the season, and therefore only  
1733 receiving basic coverage for losses.

1734  Follow the DSS recommendations at the beginning of the season and stop if they do not  
1735 suit you.

1736  Follow the DSS recommendations until the end of the campaign to be sure to benefit from  
1737 the bonus, in addition to the basic coverage.

1738 [PENALTY]

1739  Not following the DSS recommendations at the beginning of the season, and therefore  
1740 receiving the coverage reduced by the penalty of 30% in case of losses.

1741  Follow the DSS recommendations at the beginning of the season and stop if they do not  
1742 suit you.

1743  Follow the DSS recommendations until the end of the campaign to be sure to benefit from  
1744 the maximal coverage.

1745 M5: In the schemes we have proposed to you, the assessment of losses was sometimes based  
1746 on an index. Were you aware of this type of insurance before you answer this survey?

1747 *With index insurance, the compensation depends on an index and not on your own perfor-*  
1748 *mance.*

- 1749  No, I did not know about it
- 1750  Yes, I have heard of it but I have never bought it
- 1751  Yes, I have already taken out index insurance (or parametric insurance) in a professional  
1752 or private context.
- 1753 M6: What was the main reason for your interest in the insurance scheme we presented?
- 1754  Compensation for fungal disease losses
- 1755  The DSS recommendations to reduce my fungicides while maintaining yields
- 1756  Both are equally important for me
- 1757  Other:
- 1758 M7: If you were insured against climatic risks (with multiple risks, hail or frost guarantee)  
1759 at least once in the last 5 years, what was your level of satisfaction?
- 1760  I have not been insured
- 1761  Very satisfied
- 1762  Quite satisfied
- 1763  Quite dissatisfied
- 1764  Very dissatisfied
- 1765 M8: It is possible that this fungal disease insurance system could be systematically associated  
1766 with an MRC contract. What would you prefer?
- 1767  That the scheme we have presented to you remains independent of the MRC.
- 1768  That this system and the MRC are associated in a global coverage contract

1769 **Respondent's profile**

1770 N1: Did you study viticulture ?

1771  Yes

1772  No

1773 N2: What is your level of education ?

1774  No diploma

1775  Primary school certificate (CEP)

1776  Brevet des collèges (BEPC)

1777  CAP, BEP

1778  Bac or equivalent

1779  1st cycle (BTS, DUT,DEUG, Bachelor or equivalent)

1780  2nd, 3rd cycle or Grandes Ecoles (Master, DESS, DEA, Engineer, Doctorate, or equivalent)

1781  Other :

1782 N3: What is your year of birth ?

1783

1784 N4: Are you ?

1785  Male

1786  Female

1787  Other

1788 N5: Before answering this survey and watching the video, had you ever heard of the ex-  
1789 perimentation conducted within the framework of Vitirev by IFV and Groupama in Buzet and  
1790 Tutiac ?

1791  Yes

1792  No

1793 **Fungicides per grapevine growing area**

1794 After answering all these questions, you may be interested in knowing the fungicide use  
1795 of other vine growers in your wine basin. We share with you here data from the agricultural  
1796 practices survey (2019) published by the French Ministry of Agriculture. In your area (**NAME**  
1797 **OF THE REGION**, in 2019, the average Fungicide-Bactericide TFI for all vineyard was **RE-**  
1798 **GIONAL TFI** and the average number of treatments was **NUMBER OF TREATMENTS**  
1799 **In THE REGION**. [For organic producers, we also indicated the numbers for organic plots]

1800 **Comments**

1801 P1: Thank your for your participation. Your comments and suggestions in the space below  
1802 will be very useful for the analysis of the results.

1803 Do not hesitate to write us anything that comes to your mind!

1804

1805 P2: If you wish to receive the results of the study by email in 2023, please enter your email  
1806 address here.

1807 It will be stored separately from your responses and deleted once the survey is over.

1808





1809

1810 Thank you for your time in answering this questionnaire.

1811 For all question or remark: [contact email provided]

1812 [institutional logos included here]