Determinants of insurance demand against forest fire risk: Evidence from experimental and real world data

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Abstract

This article estimates the demand for forest insurance of French private forest owners against fire risk. We combine experimental and real world data and use a Heckman selection model to separately analyse insurance participation and coverage-level decisions. Our results show that some determinants explain either participation to insurance (e.g., ambiguity about the probability of occurrence of natural hazards) or coverage-level decision (e.g., the past perception of a public help in real life), some of them do not allow to explain the owner's insurance behaviour (e.g., having ever suffered from a fire in the past) while the other explain both the two behaviours (e.g., a contingent fixed help program).

JEL Classification: C51, D81, Q23, Q28.

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In the world, natural hazards, such as fire and storm, regularly destroy forests. For instance, Windstorm Kyrill in 2007 has generated more than 54 million of cubic meters of timber damages in Europe. More recently, in 2009, Windstorm Klaus has damaged 42 million of cubic meters in the South-Western part of France. In the same way, in Greece, fires have burned around 250.000 hectares in summer 2007. In European countries, storm and fire are responsible for 70% of the total forestry damages due to natural hazards, so that they are the two most important natural risks in European forest sector (Schelhaas et al. [24]).[1]

To cover against the potential damages of such natural events, above all, in some countries, non-industrial private forest owners can subscribe an insurance contract. Indeed, in several European countries, insurance companies propose contract against storm and/or fire in forest sector. However, the success of such a contract is variable between countries. For instance, in Sweden, around 90% of the private forest owners are insured against storm. In Denmark, they are more than 60%. On the contrary, in Germany around 2% of the private forest owners are concerned by insurance contract against storm and more than 50% against forest fire. In France, less than 1% of owners are insured against storm and/or fire corresponding to around 7% of the French private forest property. This observed heterogenity of insurance behaviours across countries raises many questions about the efficiency of insurance scheme. Before to interest to potential reforms of the insurance scheme, it seems relevant to wonder about the forest owners' determinants to insurance demand.

For several decades, economic literature was interested in determinants of insurance demand in various contexts but not specifically to the forest domain. Sherden [25] deals with the effect of price, income and perceived risk on the demand for three automobile insurance coverage: bodily injury, comprehensive and collision. The author shows that the demand for the three coverages is inelastic with price and income. Hopkins and Kidd [12], through simulations, underlined the effect of various characteristics such as age, income, health status and geographical location on health insurance demand. Esho et al. [8] conclude that the demand for property-casualty insurance is positively linked to loss probability and income. They also show weaker evidence of a negative relationship with price. Browne and Hoyt [2] and Sakurai and Reardon [23] deals with determinants of flood insurance demand, in United States and Burkina Faso respectively. The first authors highlight the role of income and price as determinants in flood insurance decision, while the second authors prove that the expectation of public food aid had a negative effect on demand for drought insurance. Goodwin [11] deal with demand for mutiple peril crop insurance by Iowa corn producers. The author shows

[1] Schelhaas et al. [24] indicate that over the period 1950-2000, an annual average of 35 million m^3 of wood was damaged by disturbances. Storms were responsible for 53% of the total damage, fire for 16%, snow for 3% and other abiotic causes for 5%. Biotic factors caused 16% of the damage. For 7% of the damage, no cause was given or there was a combination of causes.

the predominant role of loss-risk: counties with low loss-risks have more elastic demands than those counties where farmers are insured. Smith and Baquet [26] are also interested in demand for multiple peril crop insurance but on Montana wheat farms. This study models the farm's participation and coverage-level decisions separately through Heckman two-stage estimation procedures. They found that farms with positive expected returns from insurance make coverage-level decisions in different ways from farms with negative expected returns.

From this literature on various topics, it emerges that different categories of factors may affect the demand for forest insurance: the economic characteristics such as insurance price or income, the political characteristics such as the presence of public assistance after disaster creating a moral hazard problem[2], the characteristics of risk and risk preferences such as precise quantification of loss probability or risk aversion, and finally the individual characteristics such as the forest owner's characteristics or the component of the forest.

To our knowledge, there is no econometric analysis of the demand for forest insurance by private forest owners. Maybe one reason for this lack is due to the absence of data on insurance against forest natural risks. For that reason, to obtain data about insurance demand, an experience was realised on a sample of non-industrial forest owners located in France, that have also completed a questionnaire about the observed behaviour of insurance, and some different characteristics, in order to obtain real world data.

These experimental data combined with real world data on the forest owners (i.e., individual and property characteristics) are used to examine the determinants of insurance participation (whether or not the forest owner purchases an insurance contract) and the level of coverage chosen by forest owners who purchase an insurance contract. Such a distinction is important for two main reasons. First, it makes it possible to separately identify the causes of non-insurance of forest owners and in the same time to test the impact of factors such as the expected loss on the coverage alternatives. Second, the econometric methodology corrects the bias related to the non-random sample selection between insurance participants and non-participants. In this perspective, we specify a Heckman selection model to simultaneously estimate both insurance participation and coverage-level decisions as in Smith and Baquet [26]. However, some differences appear with the study of these authors. First, we use a combination of experimental and real world data needing to take into account the clustering of individual observations (Wooldridge [27]). Second, we simultaneously estimate the two

[2]In the forest sector, in Europe, different government assistance programs are implemented after exceptional disasters: for instance, a fixed help program in France (after Windstorm Klaus in 2009, French government provides 415 millions Euros of compensation to the forest sector), a contingent fixed help program in Denmark (Windstorm Gudrun in 2005 generated 40 millions Euros of damage in the forest sector and half were paid by Danish government), or an insurance subsidy in Germany (the Länders subsidize 50% of the fire insurance premium).

equations relative to participation to insurance and coverage-level decision.

Our results show that ambiguity about the probability of occurrence of natural hazards only explains the decision to purchase an insurance contract whereas a public help received in real life only impacts the coverage-level decision. Other determinants such as some types of public compensation explain both decisions.

The paper is structured as follows. Section 1 presents the data. Section 2 describes the model (economic and econometric). Section 3 presents the estimation results and Section 4 concludes.

1 Data

French forest insurance data are not available. Thus, our data were obtained during a field experiment realized on a sample of 42 non-industrial private forest owners located in the Aquitaine region of France. Hence, we introduce variability in some characteristics such as age or profession. The experience was developed with the assistance of the Aquitaine Regional Center of Private Forest Property. Aquitaine is one of the most important French region in terms of timber production. In this region the average forest area is 12 hectares, the more common tree species is maritime pine and the main threat is fire risk. Then, the participants were in an hypothetical framework where they owned 12 hectares of maritime pine located in Aquitaine and were exposed to a fire risk. Each participant was submitted to 8 scenarios. For each scenario, the subject is asked to indicate her/his maximum willingness to pay (WTP) to be fully covered against fire risk.

Each scenario included three pieces of information : i) the type of public help in case of disaster; ii) the average gross annual revenue that the forest generates; and iii) the probabilistic information about the risk of fire in the area where the forest is located, given as the annual probability (%) of a fire entirely destroying the forest. The first two variables were within-subject variables while the third variable was a between-subject one. The observation of WTP values and these three pieces of information are the experimental data[3]. At the end of the experience, the participants answer to a questionnaire concerning their personnal characteristics and their forest property. These are the real world data.

Before analysing the insurance responses, we detail the explanatory variables used to explain insurance participation and coverage-level decisions.

1.1 Explanatory variables

The set of explanatory variables is thus composed of a mixture of experimental and real world data.

[3]For a detailed presentation of the experiment, the reader can refer to Brunette et al. [3]

The experimental data deals with three categories of factors: type of public help, probabilistic information, and expected loss.

Type of public help.

In the experience, we consider four alternatives : no public help in case of disaster, a fixed help[4] (FH) awarded to the owner, whatever her/his insurance behaviour, a contingent fixed help (CFH) awarded to the owner only if s/he is insured and an insurance subsidy[5] (IS). Our first explanatory variable is thus the type of public help (PH).

Probabilistic Information. The experience also tested the effect of precise or ambiguous information about the probability of occurrence of fire risk on insurance behaviour. Indeed, the knowledge of an exact probability of occurrence of natural hazard is difficult due to the climate change that increases the frequencies of disasters. For that reason we consider two situations: a risky situation where the probability of occurrence of risk is well-known, and an ambiguous situation where the individuals are informed that experts give several probabilities of occurrence and that it is not possible to indicate which one is more likely than the other (Gardenförs and Sahlin [10]). In the risky case, the probability of risk occurrence is equal to 0.2%,[6]. In the ambiguous case, four potential probabilities of occurrence are provided : 0.05%, 0.15%, 0.25% and 0.35%. Consequently, our second explanatory variable, probabilistic information (PI), is binary : risky context ($PI = 0$) or ambiguous context ($PI = 1$).

Expected loss. In the experience, each forest owners face two levels of forestry revenue: a low revenue of €250/hectare/year and a high revenue of €500/hectare/year. Consequently, the expected loss of forestry revenue is represented by a binary variable taking the values €1/hectare or €0.5/hectare. The expected loss (ELOSS) represents our third explanatory variable.

The real world data deals with the characteristics of the owners and forest property.[7]

Characteristics of the owners. The characteristics of the 40 forest owners[8] and their associated statistics are given in Table 1. In our sample, around 90% of the private forest owners are male.

[4]The level is fixed to 1500 euros/ha.

[5]The subsidy corresponds to 50% of fire insurance premium.

[6]The French data base TERUTI allows us to indicate that the probability of fire occurrence in Aquitaine on the period 1981-2003 is 0.2%.

[7]Some of the statistics presented here are consistent with a French survey on forest owners (Agreste [9]). For example, this survey indicates that the main activity of French forest owners is retired and the second one is farmer. In the same way, the majority of French forest owners acquired its property by heritage.

[8]Two forest owners were removed from the sample of this study because they had just participated to the experimental part of the survey and they did not want to indicate personal information. The empirical application is based on a sample of 40 forest owners.

The majority of the owners had followed the higher education (22 owners have a baccalaureate or more). 17 owners are retired persons while the second more representated profession is farmer, with 1/4 of the owners. Very few forest owners live alone (around 7.5%) and the majority of them are two in the home. Concerning their total income, 6 owners on 40 lived with less than 1000€/month while 10 of them perceive more than 3000€/month. The category receiving the higher number of owners is 1000-2000€/month. Finally, in our sample, the forest owners have, on average, 58 years.

[Table 1 here]

Characteristics of the forest property. Summary statistics of the characteristics of the 40 forest properties are presented in Table 2. In our population, the majority of the forest properties was acquired after 1970 decade (26 properties on 40). Among our 40 forest properties, 31 are concerned by heritage in the way their owners acquired them, often linked with other mode of acquisition: purchase (13 properties), alliance (2 properties) and purchase and alliance (1 property). 95% of the forest properties are located in Aquitaine. Concerning fire risk, 18 properties have ever suffered from a fire, 9 are insured and 4 have ever perceived a public help in case of fire occurrence. Around 75% of the interviewed forest owners declare to undertake self-insurance activities in their property. In our sample, either the forest represents a little part of the patrimony (for 11 owners, forest is less than 5% of their patrimony) or it represents an important percentage (for 10 owners, forest is more than 50% of their patrimony). Finally, the average area of forest property is 241 hectares.

The characteristics of the owners and forest property (CH) are the last explanatory variable.

[Table 2 here]

1.2 Variable to be explained

We have 320 observations corresponding to the eight WTP values given by each of the 40 forest owners during the eight scenarios. The WTP given by the forest owners takes on the values of 0 to 100€/ha/year. WTP are zero for $n_1 = 41$ observations of the sample and the others are strictly positive ($n_2 = 279$). The mean for the positive values is 4€/ha/year (with a standard deviation of 10). From the WTP values, we separate insurance participation and coverage-level decisions. A positive WTP indicates the purchase of an insurance contract, and zero if the owner refuses to insure against the fire risk. The coverage-level decision refers only to positive WTP.

Table 3 presents means of explanatory variables according to participation to insurance. First, the property area of forest owners with positive WTP is around three times higher than among the null WTP (76.97 hectares against 265.16 hectares). Second, we can notice that among forest owners reporting a null WTP, very few are insured in the real world (only one null value over 41) compared to the sample of positive WTP (71 positive values over 279). Hence participants who are insured in the real world seem to be more willing to hypothetically insured their forest. Third, the profession seems to be determinant in the decision to purchase an insurance contract. Indeed, our statistics show that an employee is more enclined to indicate null value of WTP (19.51%) than a positive one (5.73%), while this is the inverse relationship for the profession Cadres (9.76% report a null value of WTP and 21.5% a positive one). Fourth, Heritage is the more common mode of forest acquisition among forest owners reporting a null value of WTP while it is the combination of Heritage and Purchase for those reporting a positive value of WTP. Fifth, with a Fixed Help, 36.58% of the WTP are null while 23.3% are positive. Sixth, in a context of ambiguity, the percentage of positive values of WTP is higher. There is an inverse link in a risky context. Ambiguity seems to encourage forest owners to purchase an insurance contract.

[Table 3 here]

The model seeks to explain the variations of WTP for insurance against fire risk. In the estimation procedure, WTP values are tranformed in log for two main reasons. First, the log transformation leads to a normal distribution of the WTP values. Second, it introduces concavity in the model, allowing to impose the risk aversion hypothesis in the behaviour of the forest owners.

2 The Model

We use a simple structural model of choice between being (totally) insured against fire risk and not being insured.[9] It is based on the random utility model (RUM, McFadden [19]). The indirect utility v of the respondent i for insurance level q_i is written as:

$$v_i = v(q_i, \mathrm{INCOME}_i, X_i, \epsilon_i), \tag{1}$$

where INCOME_i represents the total income of the i^{th} forest owner, $X_i = \{PH_i, PI_i, CH_i\}$ is the set of explanatory variables defined above, and ϵ_i is an error term for unobserved variations in

[9]This assumption of indivisibility of the amount of insurance is an acceptable estimate in the French case where the partial insurance is relatively little spread and where lots of the contracts of partial insurance are defined by insurers and do not correspond to an arbitration of insurees.

preferences. For sake of simplicity, we suppose that total insurance corresponds to $q_i = 1$ (whereas $q_i = 0$ means no insurance). Since q_i is the same for all forest owners, it does not appear anymore in our model in the rest of this section.

Let the subscripts '0' and '1' respectively denote two possible levels of utility according to the participation of insurance (1 for insurance). The forest owner i will be willing to pay the amount $t_i \geq 0$ for insurance if the utility in state '1', net to the required payment, exceeds the utility in state '0' taking into account the expected loss (ELOSS) in case of fire:

$$v_1(\mathrm{INCOME}_i - t_i, X_i, \epsilon_{1i}) \geq v_0(\mathrm{INCOME}_i - \mathrm{ELOSS}_i, X_i, \epsilon_{0i}), \tag{2}$$

For many applications, the simplest form of the indirect utility function is that where the explanatory variables enter linearly:

$$v_0 = \alpha_{01} + \alpha_{02}(\mathrm{INCOME}_i - \mathrm{ELOSS}_i) + \alpha_{03}X_i + \epsilon_{0i},$$
$$v_1 = \alpha_{11} + \alpha_{12}(\mathrm{INCOME}_i - t_i) + \alpha_{13}X_i + \epsilon_{1i}.$$

From these definitions of indirect utility, we can write:

$$v_1 - v_0 = \alpha_1 + \alpha_2\mathrm{INCOME}_i - \alpha_{12}t_i + \alpha_{02}\mathrm{ELOSS}_i + \alpha_3X_i + \epsilon_{01i}, \tag{3}$$

where $\alpha_1 = \alpha_{11} - \alpha_{01}$, $\alpha_2 = \alpha_{12} - \alpha_{02}$ and $\alpha_3 = \alpha_{13} - \alpha_{03}$. Finally, $\epsilon_{01i} = \epsilon_{1i} - \epsilon_{0i}$ is the new error term.

From equation (3) the owner's maximum WTP is given by the value $WTP_i = t_i$ that solves $v_1 - v_0 = 0$, that is

$$WTP_i = \frac{\alpha_1 + \alpha_2\mathrm{INCOME}_i + \alpha_{02}\mathrm{ELOSS}_i + \alpha_3X_i + \epsilon_{01i}}{\alpha_{12}}. \tag{4}$$

We can rewrite this regression equation as:

$$WTP_i = \beta_1 + \beta_2\mathrm{INCOME}_i + \beta_3\mathrm{ELOSS}_i + \beta_4X_i + u_i, \tag{5}$$

with $\beta_1 = \alpha_1/\alpha_{12}$, $\beta_2 = \alpha_2/\alpha_{12}$, $\beta_3 = \alpha_{02}/\alpha_{12}$, $\beta_4 = \alpha_3/\alpha_{12}$ and $u_i = \epsilon_{01i}/\alpha_{12}$. To simplify the notation, we can rewrite equation (5) as:

$$WTP_i = X_{Wi}\beta + u_i, \tag{6}$$

where $X_W = \{1, \text{INCOME}, \text{ELOSS}, X\}$ and $\beta = \{\beta_1, \beta_2, \beta_3, \beta_4\}$.

With the presence of a large number of zero responses, a classical method is to use a Tobit model for censored data. However, the censoring mechanism and the outcome variable (i.e., the WTP) may be modeled using separate processes. In our study, in explaining individual WTP for insurance against fire risk, one can first model the participation to insurance by a selection (or participation) equation:

$$Z_i^* = X_{Zi}\gamma + v_i, \tag{7}$$

where Z_i^* is a latent variable, X_{Zi} a vector of exogenous variables and γ the associated vector of parameters.[10] The set of exogeneous variables X_Z can in theory be exactly the same as X_W because of the (non linear) parametric assumptions on the distribution of errors. In some cases, it is possible to have identification problems when any restriction on the regressors is made. However, in many applications as in ours, it can be very difficult to make defensible exclusion restrictions.

The second process may explain the WTP associated with the participation to insurance:

$$WTP_i = \begin{cases} X_{Wi}\beta + u_i & \text{if} \quad Z_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \tag{8}$$

The parameters β and γ of the sample selection model composed of equations (7) and (8) can be efficiently estimated by full maximum likelihood method. u_i and v_i are the random disturbances following a bivariate normal distribution: $(u_i, v_i) \sim BVN(0, 0, \sigma, 1, \rho)$, with zero means, ρ the correlation coefficient (between u_i and v_i) and σ the variance of u_i. Both parameters ρ and σ are to be estimated.

3 Results

3.1 Preliminaries: clustering and adjustment

In our experiment, each forest owner reports as many WTP as they are scenarios (eight in total). Hence, we have to take into account the clustering of individual observations (Wooldridge [27]). In particular, the standard errors are biased when we use usual estimation methods such as ordinary least squares or maximum likelihood, because of the presence of an unobserved cluster effect in the error term. In our estimation, the standard errors are corrected to allow intra-subject (i.e., forest owner) correlation. Estimates of the complete model (regression and selection equations) are

[10] The sample rule is $Z_i = 1$ if $Z_i^* > 0$ and 0 otherwise, and can be represented by a Probit model: $P(Z_i = 1) = \Phi(X_{Zi}\gamma)$, where $\Phi(.)$ is the standard normal cumulative distribution function.

reported in Table 4.

[Table 4 here]

Before commenting estimation results, it is important to do some remarks on the adjustment of the model. First, the null hypothesis that ρ is zero is largely rejected at the 1% level, indicating the validity of jointly estimate the participation to insurance (selection equation) and the coverage-level decision (WTP equation). Second, the reported model χ^2 test (a Wald test) testing that all coefficients in the regression equation (except the constant) are 0, shows that the regressors explain globally well the variations in WTP values.

3.2 Determinants of insurance participation and coverage level decisions

Impact of public help

First regarding the effect of fixed help and contingent fixed help, intuitive behaviors are found. Indeed, the variable FH has a significant and negative impact on participation to insurance at the 1% level (Coef. = -0.534). This means that a fixed help discourages owner to subscribe insurance contract. This empirical results validate the theoretical conclusion that government assistance reduces the optimal insurance level (Kaplow [14]; Coate [6]; Kim and Schlesinger [15]; Raschky and Weck-Hannemann [21], Brunette and Couture [4]). This result reflects the so-called 'Charity Hazard' defined by Browne and Hoyt [2]. Consequently, the forest owners' failure to insure could be a consequence of the compensation provided by government disaster relief programs. The variable CFH has a significant and positive impact on participation to insurance (Coef. = 0.291) and a significant and negative effect on coverage level decision (Coef. = -0.600). On the one hand, in order to perceive a contingent fixed help, the forest owner is constrained to take out insurance, so that it is a really persuasive mean to increase the participation to insurance. On the other hand, when government awards a contingent fixed help, then the owner's WTP is decreased compared to a situation with no public help. This behaviour is consistent with the intuition because, when the owner receives a public help, s/he needs a lower insurance indemnity to keep a constant level of coverage. In case of disaster, a part of the loss is covered by insurance and the other part by government's compensation. It appears a kind of 'complementarity' between insurance demand and public help. This result is also coherent with the theoretical conclusion of Brunette and Couture [4] showing that a fixed public help contingent to insurance subscription incites more to insurance than a fixed help independent of insurance behaviour.

Second, more surprisingly, insurance subsidy (IS) has no effect both on individual's participation to insurance and coverage level decision. This result is contradictory with the theoretical results that insurance subisidy can induce over insurance (Brunette et al. [3]). These results are more in accordance with the empirical results obtained by Kunreuther [16]. He has showed that with a subsidised insurance, half of the Californian households interviewed subscribes an insurance contract against earthquake.

Among these three public programs, it seems that the contingent fixed help is better to encourage forest owner to indicate a positive WTP for insurance than the others.

Impact of probabilistic information

The variable PI has a significant and positive impact at the 5% level on participation to insurance (Coef. = 1.136), but not on the coverage level decision. This implies that, in presence of ambiguity concerning the probability of occurrence of fire, the forest owner wants to transfer risk to insurance company more than when the probability of occurrence of fire is precise. This result seems to suggest that, in a context where climate change modifies the frequency of fire and leads to imprecision in estimation of risk, the individuals will use more insurance contract. More, this result confirms the theoretical conclusion that ambiguity raises the level of insurance coverage (Brunette et al. [3]; Alary et al. [1]).

Impact of expected loss

The variable ELOSS has a significant and positive effect both on participation to insurance (Coef. = 0.454) and on coverage level decision (Coef. = 4.841). This means that as the expected loss increases, the forest owner's incentives to insure raise and the amount that s/he is ready to pay to be fully covered also raises. The higher the profitability of forest is (i.e., the higher the potential loss is), the more the forest owner is enclined to insure and the higher the insurance level is. This result may explain the under-insurance of French private forest owners. Indeed, the French private forest area is very divised with 10.6 millions of hectares for 3.5 millions of owners (Puech [20]) underlying the low profitability of some properties.

Impact of forest and forest owners characteristics

Concerning the personal characteristics of forest owners, two main results appear. First, to be a farmer has a significant and positive effect on participation to insurance (Coef. = 2.392) and a significant and negative effect on coverage-level decision (Coef. = -5.475). Lönnstedt and Svensson

[18] indicate that *"forest owners who works actively with farming and forestry are prepared to take risks in the areas that they know best"*. This suggests that our farmers sample knows best the farming and prefer to take risk in this domain, while choosing to insure the forestry activity.

Second, it appears that belonging to the category of retired person increases the probability to insure (Coef. = 1.985). Indeed, the main objective of these forest owners is a patrimony transmission increasing the desire to cover against risk.

Concerning the characteristics of forest stand, four main results are observed. First, if the owner is insured in the real world (proxied by the variable Contract), then s/he is more enclined to adopt an insurance policy. This result seems coherent: as the owner has already subscribed an insurance in the real world, there is no reason why s/he refuses to pay an insurance in hypothetical situation.

Second, the variable Self indicating the implementation of self-insurance activities by the forest owners, has a significant and negative impact on participation to insurance (Coef. = -0.790). This means that if owner undertakes activity such as clearing, then s/he is less ready to also subscribe insurance policy because the fire risk is less. This result suggests substitutability between insurance and self-insurance, according to the well-known theoretical result of Ehrlich and Becker [7].

Third, the decade of forest acquisition seems to play a significant role in the owner's participation to insurance (Coef. = 0.397). The more the forest is acquired recently, the more the owner is encouraged to adopt insurance against fire. This result can be justified by the recent observed increase of disaster occurrence, rising the awareness of risk.

Finally, the fact to have ever perceived a public compensation in the real world (Public-Help) has a significant and negative effect on coverage-level decision (Coef. = -4.135). This negative relationship between public help and insurance is in line with the existing theoretical results mentioned before.

Surprisingly, we note that some factors do not affect both participation to insurance and coverage level decision. For instance, the variable Fire, which indicates whether the forest owner has suffered from a fire in the past, has no effect. This result can prove the existence of a "Gambler Fallacy Effect", i.e. the tendency of individuals to underestimate the probability of occurrence of an event already observed (Laplace [17]; Roney and Trick [22]). This effect may lead the owner to not insure. In the same way, the variable INCOME, representing the total income of the forest owners, has no impact. A reason is that the consistent variable here is the forestry income represented by the variable ELOSS which has a significant and positive effect both on participation to insurance and coverage level decision. Finally, as the variable Area does not appeared in our estimation, it seems that forest owners' insurance choice is not sensitive to forest area.

4 Conclusion

This paper analyzed the forest owner's participation to insurance and coverage-level decision against fire risk. In particular, we try to explain why some forest owners are insured while others are not, focusing on four explanatory variables. The first one indicates that among the three types of public help tested, two impacts the forest owners' insurance decision process. Indeed, the Danish contingent fixed help seems to encourage owners to participate to insurance while the French fixed help could explained the under-insurance of French private forest owners. Our second explanatory variable, the probabilistic information, lets appeared that ambiguity on probability of natural risk occurrence leads to an increase in participation to insurance. The third explanatory variable shows that the higher the expected loss (due to higher forest income or to higher risk) is, the more the incentives to insure and the coverage-level decision are. Finally, some forest owner's characteristics play an important role such as profession. Some forest property's characteristics are also of interest such as decade of forest acquisition, insurance contract in the real world or the fact to have ever perceived a public help.

These results are of particular interest in a context of climate change because countries should face much more frequent natural hazards with higher damages and, they should adapt their current forest insurance scheme. Our results suggest that the more efficient type of public help, in terms of incentives to coverage, is the contingent fixed help. This system, currently used for storm risk, could be extended to forest fire in France and consequently, represents a potential solution to incite forest owners to adopt insurance. The implementation of contingent fixed help could have several positive consequences for the French policymaker. First, as it incites the forest owner to adopt insurance policy, this system can contribute to the reduction of public funds engaged in compensation of victims and, on that account increases firefighting budget. Second, the cost of this implementation can be very low compared to a deeper reform of the French forest insurance scheme. Indeed, as in Denmark, the French government can entrust the insurance companies proposing policy against forest fire to distribute the public help, at the same time of insurance indemnity.

References

[1] D. Alary, C. Gollier, and N. Treich. The effect of ambiguity aversion on insurance demand. *Paper presented at the World Risk and Insurance Economics Congress*, Singapore, 2010.

[2] M.J. Browne and R.E. Hoyt. The demand for flood insurance: Empirical evidence. *Journal of Risk and Uncertainty*, 20(3):291–306, 2000.

[3] M. Brunette, L. Cabantous, S. Couture, and A. Stenger. Assurance, intervention publique et ambiguïté : une étude expérimentale auprès de propriétaires forestiers privés. *Economie et Prévision*, 4-5(190-191):123–134, 2009.

[4] M. Brunette and S. Couture. Public compensation for windstorm damage reduces incentives for risk management investments. *Forest Policy and Economics*, 10(7-8):491–499, 2008.

[5] S. Coate. Altruism, the samaritan's dilemma, and government transfer policy. *The American Economic Review*, 85(1):46–57, 1995.

[6] I. Ehrlich and G. Becker. Market insurance, self-insurance and self-protection. *Journal of Political Economy*, 80(4):623–648, 1972.

[7] N. Esho, A. Kirievsky, D. Ward, and R. Zurbruegg. Law and the determinants of property-casualty insurance. *The Journal of Risk and Insurance*, 71(2):265–283, 2004.

[8] Agreste: Chiffres et données. Structure de la propriété forestière privée en 1999. 144, 2002.

[9] P. Gardenförs and N.E. Sahlin. Unreliable probabilities, risk taking, and decision making. *Synthese*, 53:361–386, 1982.

[10] B.K. Goodwin. An empirical analysis of the demand for multiple peril crop insurance. *American Journal of Agricultural Economics*, 75(2):425–434, 1993.

[11] S. Hopkins and M.P. Kidd. The determinants of the demand for private health insurance under medicare. *Applied Economics*, 28(12):1623–1632, 1996.

[12] L. Kaplow. Incentives and government relief for risk. *Journal of Risk and Uncertainty*, 4(2):167–175, 1991.

[13] B.J. Kim and H. Schlesinger. Adverse selection in an insurance market with government-guaranteed subsistence levels. *Journal of Risk and Insurance*, 72(1):61–75, 2005.

[14] H.C. Kunreuther. Limited knowledge and insurance protection. *Public Policy*, 24:227–261, 1976.

[15] P.S.De Laplace. A philosophical essay on probabilities. *Republished by Dover (New York) in 1951*, 1796.

[16] L. Lönnstedt and J. Svensson. Non-industrial private forest owner's risk preferences. *Scandinavian Journal of Forest Research*, 15:651–660, 2000.

[17] D. McFadden. Conditional logit analysis of qualitative choice behavior, 1974. in *Frontiers Econometrics*, edited by P. Zarembka, New York: Academic Press, 105–142.

[18] J. Puech. Mise en valeur de la forêt française et développement de la filière bois. *Rapport remis à Mr Nicolas Sarkozy, Président de la République*, 6 avril 2009.

[19] P.A. Raschky and H. Weck-Hannemann. Charity hazard - a real hazard to natural disaster insurance? *Environmental Hazard*, 7:321–329, 2007.

[20] C. Roney and L. Trick. Grouping and gambling: a gestalt approach to understanding the gambler's fallacy. *Canadian Journal of Experimental Psychology*, 57(2):69–75, 2003.

[21] T. Sakurai and T. Reardon. Potential demand for drought insurance in burkina faso and its determinants. *American Journal of Agricultural Economics*, 79(4):1193–1207, 1997.

[22] M.J. Schelhaas, G.JL. Nabuurs, and A. Schuck. Natural disturbances in the european forests in the 19th and 20th centuries. *Global Change Biology*, 9:1620–1633, 2003.

[23] W.A. Sherden. An analysis of the determinants of the demand for automobile insurance. *The Journal of Risk and Insurance*, 51(1):49–62, 1984.

[24] V.H. Smith and A.E. Baquet. The demand for multiple peril crop insurance: Evidence from montana wheat farms. *American Journal of Agricultural Economics*, 78(1):189–201, 1996.

[25] J.M. Wooldridge. Cluster-sample methods in applied econometrics. *American Economic Review*, 93(2):133–138, 2003.

Table 1: Indiviual characteristics of forest owners (real world data)

Variable	Definition	Nb of individuals	%
Male	**Gender**	35	87.5
	(Dummy variable, 1 for Male)		
Education	**Education level**[a]		
	(treated as a continuous variable)		
	Cat. 1 : General Certificate of Secondary Education	13	37.1
	Cat. 2 : High school diploma	7	20
	Cat. 3 : High school diploma +2, +3 and +4 years	7	20
	Cat. 4 : High school diploma + 5 and more	8	22.9
	Profession		
	(Dummy variables)		
Retired	Retired persons	17	42.5
Farmer	Farmers	10	25
Intermediate	Intermediate professions	1	2.5
Employee	Employees	3	7.5
Cadres	Cadres	8	20
Others	Others	1	2.5
INCOME	**Total income**		
	(treated as a continuous variable)		
	Cat. 1 : <1000	6	15
	Cat. 2 : 1000-2000	11	27.5
	Cat. 3 : 2000-2500	9	22.5
	Cat. 4 : 2500-3000	4	10
	Cat. 5 : >3000	10	25
		Mean	Std. Dev.
Age	**Age** (in years)	58.18	12.11
Pers	**Number of persons in the home**	2.56	0.95
Child	**Number of children**	0.90	1.12

Note: Total number of forest owners $N = 40$.

[a] In the initial database, 5 forest owners do not answer this question. We complete these missing data by the mean value.

Table 2: Characteristics of owners' forest property (real world data)

Variable	Definition	Nb of individuals	%
Acquisition	**Mode of forest acquisition**		
	(Dummy variables)		
	Heritage	15	37.5
	Purchase	7	17.5
	Alliance	2	5
	Heritage and purchase	13	32.5
	Heritage and alliance	2	5
	Heritage, purchase and alliance	1	2.5
Dec-Acquis	**Decade of forest acquisition**		
	(treated as a continuous variable)		
	Cat. 1 : 1940	4	10
	Cat. 2 : 1950	3	7.5
	Cat. 3 : 1960	4	10
	Cat. 4 : 1970	3	7.5
	Cat. 5 : 1980	8	20
	Cat. 6 : 1990	13	32.5
	Cat. 7 : $<$ 10 years	5	12.5
%Forest	**% of forest in the patrimony**		
	(treated as a continuous variable)		
	Cat. 1 : $< 5\%$	11	27.5
	Cat. 2 : $5 - 10\%$	1	2.5
	Cat. 3 : $10 - 15\%$	4	10
	Cat. 4 : $15 - 20\%$	3	7.5
	Cat. 5 : $25 - 30\%$	6	15
	Cat. 6 : $35 - 40\%$	4	10
	Cat. 7 : $45 - 50\%$	1	2.5
	Cat. 8 : $> 50\%$	10	25
Dummy variables, 1 for yes			
Aquitaine	**Forest exclusively located in Aquitaine**	38	95
Public-Help	**Public help**	4	10
Fire	**Fire occurrence**	18	45
Self-Insur	**Self-insurance activities**	30	75
Contract	**Fire insurance contract**	9	22.5
		Mean	Std. Dev.
Area	**Area of forest property** (in hectares)	241	357.88

Note: Total number of forest owners $N = 40$

Table 3: Insurance decision

Variable	WTP null (n_1=41)	WTP positive (n_2=279)
Experimental data		
Type of public help		
No public help	21.95%	25.45%
Fixed help	36.58%	23.30%
Contingent fixed help	14.63%	26.52%
Insurance subsidy	26.83%	24.73%
Expected loss		
Low	53.66%	49.46%
High	46.34%	50.54%
Probabilistic information		
Ambiguity	31.71%	41.22%
Risk	68.29%	58.78%
Real world data		
Characteristics of the forest owners		
Education level (average category)	1.66	2.38
Retired persons	39.02%	43.01%
Farmers	24.39%	25.09%
Intermediate professions	0%	2.87%
Employees	19.51%	5.73%
Cadres	9.76%	21.50%
Others	7.32%	1.79%
Total income (average category)	2.41	3.11
Age (in years)	58.27	58.16
Number of persons in the home	2.32	2.58
Number of children	0.88	0.90
Characteristics of the forest property		
Heritage	56.10%	34.77%
Purchase	29.27%	15.77%
Alliance	2.44%	5.38%
Heritage and purchase	12.19%	35.48%
Heritage and alliance	0%	5.73%
Heritage, purchase and alliance	0%	2.87%
Decade of forest acquisition (average category)	3.32	4.87
% of forest in the patrimony (average category)	3.83	4.54
Forest exclusively located in Aquitaine	92.68%	95.34%
Public help	4.88%	10.75%
Fire occurrence	39.02%	45.88%
Self-insurance activities	75.61%	74.91%
Fire insurance contract	2.44%	25.45%
Property area (in hectare)	76.97	265.16

Table 4: Estimation results of the selection model

Variable	Coefficient	Robust Std. Err.
WTP equation		
Intercept	16.358*	8.660
INCOME	-0.568	0.662
ELOSS	4.841**	2.050
FH	0.564	0.671
CFH	-0.600*	0.324
IS	2.177	1.811
Pers	-5.002	3.259
Child	2.624	1.857
Retired	-3.448	3.611
Farmer	-5.475**	2.612
Public-Help	-4.135**	2.103
Selection equation		
Intercept	-3.635**	1.446
INCOME	0.207	0.287
ELOSS	0.454*	0.267
FH	-0.534***	0.155
CFH	0.291**	0.141
IS	-0.106	0.185
PI	1.136**	0.503
Pers	0.599	0.458
Child	-0.769	0.498
Retired	1.985**	0.887
Farmer	2.392***	0.881
Public-Help	0.061	0.605
Contract	3.279*	1.822
Dec-Acquis	0.397**	0.166
Self-Insur	-0.790*	0.433
ρ	-0.618***	0.216
σ	9.337***	2.630
Wald test of independent eqns: $\rho = 0$		
$\chi^2_{(1)}$	18.44	(0.0000)
Log-likelihood	-1086.346	
$\chi^2_{(10)}$	21.11	(0.0204)

Notes: N=320, Censored N=41.
Significance levels: $***$: 1% $**$: 5% $*$: 10%.
Standard errors robust to within-cluster correlation.