

## **Insurance demand under ambiguity and conflict for extreme risks: Evidence from a large representative survey**

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Résumé de l'article

Ce papier vise à comprendre les comportements d'assurance du grand public face à l'ambiguïté et aux risques de faible probabilité. À travers un questionnaire complété par un large échantillon représentatif de la population française, l'objectif est d'identifier les attitudes vis-à-vis du risque, de l'imprécision et du conflit et de déterminer la demande d'assurance pour des risques extrêmes et ambigus. Les résultats montrent deux décisions distinctes : la décision d'acheter de l'assurance et la décision du consentement maximal à payer. Dans la première décision, plus de 25% des sujets refusent de s'assurer et les individus sont plus enclins à s'assurer en présence de risque que d'ambiguïté. Ce goût pour le risque s'explique en partie par les caractéristiques des individus, et révèle un manque de confiance dans le marché de l'assurance. En ce qui concerne la seconde décision, les individus ont un goût pour l'ambiguïté (incluant l'imprécision et le conflit). Ils considèrent les situations ambiguës comme inférieures et sont moins prêts à payer. En outre, les individus se comportent différemment dans l'imprécision et dans le conflit. Ils préfèrent lorsque l'information est consensuelle et n'aiment pas les conflits. Cependant, les consentements à payer ne sont pas corrélés avec les caractéristiques observables.

## **Insurance demand under ambiguity and conflict for extreme risks: Evidence from a large representative survey**

**by Théodora Dupont-Courtade**

### **ABSTRACT**

This paper investigates how the general public behaves when confronted with low probability events and ambiguity in an insurance context. It reports the results of a questionnaire completed by a large representative sample of the French population that aims at separating attitudes toward risk, imprecision and conflict and at determining if there is a demand for ambiguous and extreme event risks. The data show a strong distinction between two aspects of the problem: the decision of purchasing insurance and the willingness to pay. In the decision to insure, more than 25% of the respondents refuse to buy insurance and people are more willing to insure in a risky situation than in an ambiguous one. This certain taste for risk can be explained by the respondents' observable characteristics. In addition, it highlights a lack of confidence in the insurance markets. When it comes to willingness to pay, people exhibit ambiguity seeking behaviors. They are willing to pay more under risk than under ambiguity (embracing here imprecision and conflict), revealing that people consider ambiguous situations as inferior. Furthermore, respondents behave differently under imprecision and conflict. They exhibit a preference for consensual information and dislike conflicts. However, the willingness to pay is poorly correlated with observable characteristics.

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**Keywords:** Ambiguity, imprecision, conflict, decision, extreme risk, insurance demand, willingness to pay.

**JEL Classification Numbers:** C93, D81, D83, Q54.

## RÉSUMÉ

Ce papier vise à comprendre les comportements d'assurance du grand public face à l'ambiguïté et aux risques de faible probabilité. A travers un questionnaire complété par un large échantillon représentatif de la population française, l'objectif est d'identifier les attitudes vis-à-vis du risque, de l'imprécision et du conflit et de déterminer la demande d'assurance pour des risques extrêmes et ambigus. Les résultats montrent deux décisions distinctes: la décision d'acheter de l'assurance et la décision du consentement maximal à payer. Dans la première décision, plus de 25% des sujets refusent de s'assurer et les individus sont plus enclins à s'assurer en présence de risque que d'ambiguïté. Ce goût pour le risque s'explique en partie par les caractéristiques des individus, et révèle un manque de confiance dans le marché de l'assurance. En ce qui concerne la seconde décision, les individus ont un goût pour l'ambiguïté (incluant l'imprécision et le conflit). Ils considèrent les situations ambiguës comme inférieures et sont moins prêts à payer. En outre, les individus se comportent différemment dans l'imprécision et dans le conflit. Ils préfèrent lorsque l'information est consensuelle et n'aiment pas les conflits. Cependant, les consentements à payer ne sont pas corrélés avec les caractéristiques observables.

**Mots-clés:** Ambiguïté, imprécision, conflit, décision, risque extrême, demande d'assurance, consentement à payer.

## I. INTRODUCTION

The assessment of the risk characteristics, i.e. the faculty of correctly evaluating the potential losses and the associated occurrence probability, is an important condition of the insurability of a risk because it allows the use of actuarial methods for pricing insurance contracts. However, our societies are confronted with risks which do not verify this condition, as is the case for extreme events, like natural hazards, environmental pollution or new technologies. The magnitude of the occurrence probability of the event is difficult to estimate, especially due to the non-availability of historical records, changing environments and new regulations. On the insurance markets, insurers have to incorporate this uncertainty in the premium estimation, but the demand can respond differently, and the way insureds will react to extreme events could cause disruption to insurance markets.

The decisions concerning these events are not taken in a risky environment where it is possible to define precise probabilities for the events, but in an uncertain environment where the information is not

complete, namely an ambiguous situation. The subjective expected utility theory (Savage 1954) allows treating a decision under ambiguity as a decision under risk, with a subjective probability distribution replacing the objective one (known in the precise environment). However, many works have shown that the notions of risk and ambiguity are treated differently (Ellsberg, 1961). This distinction has led to the separation between risk and ambiguity aversions. Ambiguity aversion depends on affective reactions; a risky and familiar bet being more attractive than an ambiguous and unfamiliar one (Rubaltelli et al, 2010). Furthermore, people seem to behave differently according to the source of ambiguity, separating here attitudes toward imprecision and conflict. Imprecision refers to a situation in which the information is consensual but imprecise; and conflict refers to a situation of disagreement between experts. Smithson (1999) defines conflict aversion as the fact that individuals prefer a consensual information over a controversial one. He explains that conflicts are perceived as less credible and trustworthy. This paper intends to understand decisions regarding the insurance demand for extreme events coping with risky, imprecise and conflicting situations.

Insurance markets represent a promising context for empirical studies as the decisions deal with risk estimation. Hershey and Schoemaker (1980) highlight an insurance context effect, risk aversion being stronger in a real environment rather than in non-contextual lotteries. In addition, extreme risks lead to different behaviors than more common risks. Hershey and Schoemaker (1980) observe an overestimation of low-probabilities and an underestimation of large-probabilities, revealing that fair insurance should be more attractive for low probability risks, which is consistent with Kahneman and Tversky's (1979) prospect theory. However, individuals prefer purchasing insurance for large-probability small-loss events, rather than low-probability high-loss events (Slovic et al, 1977; Loubergé and Outreville, 2001; Laury et al, 2009). The possibility of learning over time being limited, the occurrence probability estimation cannot always be adjusted. Individuals have a short term vision and prefer taking protection against most likely losses. Actually, bimodal behaviors are found in other empirical studies (Kunreuther, 1978; McClelland et al, 1993; Schade et al, 2004), revealing that people are either scared of extreme risks and pay a premium well in excess of the expected loss, or ignore them completely and do not insure. An explanation could be that individuals appreciate the likelihood of rare events contingent to their past experience (Kahneman et al, 1982). Then, insurance decisions do not only lean upon the need for protection through an arbitrage between the costs and benefits, and observable characteristics can help understand the underlying factors.

Furthermore, insurance decisions also vary in presence of ambiguity. When adding ambiguity, Schade et al (2004) observe a higher number of people willing to insure and large ambiguity aversion in the willingness to pay. Hogarth and Kunreuther (1985) find ambiguity aversion for low-probability events, but ambiguity preference for large-probability events. In a similar fashion, Kunreuther et al (1993) reveal that insurers also exhibit ambiguity aversion and demand a higher premium when the probability is ambiguous. However, these papers include ambiguity through comments explaining the uncertain situation around a best estimate; the ambiguity source is not defined. Di Mauro and Maffioletti (2001) study the impact of different definitions of ambiguity on the willingness to buy insurance. They distinguish the best estimate<sup>1</sup>, the interval of probability, and the set of probability; but they do not notice major differences between the three representations (and they do not cope with extreme events). Cabantous (2007) and Cabantous et al (2011) reveal that insurers are sensitive to the ambiguity source. They test for imprecision aversion (Ellsberg, 1961) characterized by a consensual information that the true value of the probability ranges within an interval, and for conflict aversion (Smithson, 1999) when multiple sources of information lead to a disagreement on the value of the probability. They find that insurers exhibit stronger conflict aversion than ambiguity aversion, i.e. insurers dislike conflicting information and prefer consensual information. In addition, insurers seem to be slightly risk averse but highly ambiguity averse. These papers study non-contextual lotteries or insurance supply, but it seems that there is no paper analyzing insurance demand, especially of the general public, dealing with imprecision and conflict.

The analysis of insurance demand behaviors allows to compare the results for both sides of the market (insureds and insurers). Indeed, in a free market, supply has to meet demand. If the insurers only accept a very high premium for extreme risks under ambiguity (Cabantous et al, 2011), is there a demand for coverage for these same risks? People might not be as ambiguity averse, and therefore a market does not necessarily exist. How does the insurance demand for ambiguous risks stand in comparison to insurance demand for well-known risks? Is it possible to explain the insurance demand from the risk characteristics and the socio-demographic factors? How do individuals perceive imprecise and conflicting situations in extreme event risks? This paper aims at producing new results on risk and ambiguity perceptions in relation with individual observable characteristics. The main objective is to reveal insurance demand behaviors, separating the attitudes toward

risk, imprecision and conflict; and to find a set of determinants for these behaviors, based on socio-demographic characteristics. This paper is part of a larger project including the behavioral study of insurance professionals in order to provide new insights on the insurance markets of extreme and ambiguous risks.

A questionnaire was administered to a large representative sample of the French population in order to put in relation insurance demand with socio-demographic characteristics. The final sample replicates the structure of the French population based on quotas from the last census report. Respondents had to give their willingness to pay for an insurance contract covering a low-probability risk and under a specific information type (risk, imprecision or conflict). Imprecision, here, refers to a situation in which the information is imprecise and consensual (experts agree on a vague estimate); and conflict refers to a situation in which the information is precise and controversial (experts disagree but each have a precise estimate). Subjects had the choice between buying insurance and revealing their maximum insurance premium, and not buying insurance and risking the loss.

The main results were as follows. Firstly, the decision to insure and the decision of the insurance premium portray two different actions with specific determinants. In particular, 25% of the respondents refuse to buy insurance and that decision can be explained by the age, the education level, the insurance claims and the past experience linked to extreme events. Secondly, risk and ambiguity lead to different behaviors. The results show that people are more willing to buy insurance and to pay a higher premium in the presence of risk than in the presence of ambiguity. They exhibit ambiguity seeking behaviors, because they consider ambiguous situations as being inferior. Furthermore, people show a lack of confidence in the insurance markets; they have doubts about the reimbursements in case of a loss event. Thirdly, respondents exhibit conflict aversion. They would pay a higher premium under conflict than under imprecision, which reveals a preference for consensual information.

The paper is structured as follows. The second section summarizes the main points of the literature on decision making under ambiguity from a theoretical point of view. The third section introduces the predictions and the experimental design of the survey. The fourth section presents the survey results, divided between the insurance decision per se and the willingness to pay. In concluding, the paper discusses the results and raises questions for further research.

## 2. INSURANCE DEMANDE UNDER RISK AND AMBIGUITY: SOME THEORETICAL BACKGROUND

The expected utility model has long been the main model for preferences representation under risk. It has been extended in the subjective expected utility (SEU) model proposed by Savage (1954), which allows to model a decision under ambiguity as a decision under risk, with a subjective probability distribution replacing the objective one. It assumes that each decision maker is able to have a precise idea of the probability distribution, even if it is subjective. However, the axioms are not always verified (Ellsberg, 1963), and the SEU model is not able to separate risk and ambiguity attitudes. Therefore, several models have been proposed to represent the preferences according to the available information.

In this part, we give some basic results on the willingness to pay for full coverage under three different information types (risk, imprecision and conflict) in a simple, two-state of nature insurance problem. Consider an individual with an initial wealth  $w$  who faces a risk of loss  $l$ .  $S = \{L ; \bar{L}\}$  is the state space with  $L = \{Loss\}$  and  $\bar{L} = \{No\ loss\}$ . The outcome space  $X$  represents money and a decision is a couple  $(a; b)$  where  $a$  is the individual's wealth if a loss occurs and  $b$  if no loss occurs. Then, two main decisions can be made:

- The decision maker can decide not to buy insurance:  $f = (w - l ; w)$ . The outcome of decision  $f$  depends on the probability distribution of loss between the two states.
- The decision maker can decide to buy full insurance at a premium  $\pi$ :  $g = (w - \pi ; w - \pi)$ . The outcome of decision  $g$  is not impacted by the states of nature.

The individual evaluates decisions based on their preferences and beliefs of the risk characteristics. Let  $V$  be the value attached to these decisions. Then, the decision maker will prefer a decision over another by comparing  $V(f)$  and  $V(g)$ . We will contemplate different functional forms for  $V$ . For all of them the decision  $g$ , which entails no exposure to any uncertainty, will be evaluated by  $V(g) = u(w - \pi)$ , where  $u : X \rightarrow R$  is a monotonic, increasing and concave utility function over outcomes. Furthermore, we are interested here in the maximum premium the individual is willing to pay for full coverage, i.e. the premium which makes one indifferent between buying and not buying insurance:  $\pi$  such that  $V(f) = V(g)$ .

## 2.1 Insurance decision for well-estimated risk

In situations of precise risk, the decision maker has enough information to precisely estimate the probability distribution ( $p$ ;  $1 - p$ ), where  $p$  is the probability of state  $L$  and  $(1 - p)$  the probability of state  $\bar{L}$ . With SEU preferences, the value of decision  $f$  is:

$$V_{SEU}(f) = p u(w - l) + (1 - p) u(w).$$

The willingness to pay  $\pi$  for full coverage is the solution of  $u(w - \pi) = p u(w - l) + (1 - p) u(w)$ . If the utility function is concave, reflecting diminishing marginal utility and risk aversion under SEU, then, from Jensen's inequality, we have:

$$u(w - pl) > p u(w - l) + (1 - p) u(w) \Leftrightarrow \pi > pl.$$

Therefore, for risk averse individuals, the maximum premium they are willing to pay is strictly higher than the expected loss ( $pl$ ). Furthermore, there exists only one  $\pi$  that maximizes  $u(w - \pi) = V_{SEU}(f)$  (Mossin, 1968). With SEU preferences and concave  $u$ :  $\pi_{SEU} \in ]pl; l]$ . For risk neutral individuals ( $u$  is linear), the willingness to pay is the expected loss ( $\pi = pl$ ).

## 2.2 Insurance decision under ambiguity

In situations of ambiguous risk, the decision maker has an imprecise knowledge of the probability distribution. The information is defined as a set  $P$  of probability distributions in which lies the true probability. In our insurance problem,  $P = \{p; 1 - p \mid p \in [p_{min}; p_{max}]\}$ , the decision maker only knows that the probability of loss ranges between  $p_{min}$  and  $p_{max}$ . The actuarial expected probability is equal to  $p = 1/2 (p_{min} + p_{max})$ . In this way, the decisions under ambiguity can be compared with the decisions under risk.

Several models have been proposed in order to model ambiguous situations. In particular, the maxmin expected utility (MaxMinEU) model of Gilboa and Schmeidler (1989) considers that the decision maker evaluates a decision by computing its minimal expected utility on a subjective space state. For a decision  $f$ :

$$V_{MaxMinEU}(f) = \text{Min}_{p \in P} E_p u(f).$$

With MaxMinEU preferences, our decision maker will only take into account the worst probability distribution, i.e. the highest loss probability:  $V_{MaxMinEU}(f) = p_{max} u(w - l) + (1 - p_{max}) u(w)$ . Then,  $V_{SEU} > V_{MaxMinEU}$ , a risky situation is always preferred to an imprecise one when  $p$  is the center of the interval  $[p_{min}; p_{max}]$ . Furthermore, in terms



of willingness to pay,  $\pi$  is the solution of  $u(w - \pi) = V_{MaxMinEU}(f)$ . A risk averse individual will have a maximum premium of  $\pi_{SEU} > p_{max}l$ . A risk neutral individual will be willing to pay exactly  $p_{max}l$ .

The alpha maxmin expected utility model ( $\alpha$ MaxMinEU) of Ghirardato et al (2004) allows to generalize the MaxMinEU model in taking into account both the minimal and the maximal expected utility<sup>2</sup>. In addition, the model with second order beliefs (Klibano et al, 2005) assumes that the individual has a set of beliefs over  $P$  that measures how much they weight the possibility of  $p \in P$  being the correct value<sup>3</sup>.

However, in our insurance context, the information is imprecise but objective. If we assume the set  $P$  of MaxMinEU to be objective information, the decision maker exhibit extreme ambiguity aversion. It is more appropriate to use a model that captures objective imprecise information (Gajdos et al, 2008). In our special case with only two states of nature, this model is similar to  $\alpha$ MaxMin. Gajdos et al (2008) (GHTV) represent preferences in taking a convex combination of the minimum expected utility with respect to all  $P$ , and the expected utility with respect to a precise  $p$  in  $P$ . Therefore, a decision  $f$  can be evaluated as follows:

$$V_{GHTV}(f) = \alpha \text{Min}_{p \in P} E_p u(f) + (1 - \alpha) E_p u(f)$$

where  $\alpha$  represents the attitude towards imprecise information, and  $p = 1/2 (p_{min} + p_{max})$  is the actuarial expected loss. Then, the decision  $f$  is computed as:

$$V_{GHTV}(f) = \alpha [p_{max} u(w-1) + (1-p_{max}) u(w)] + (1-\alpha) [p u(w-1) + (1-p) u(w)].$$

In terms of willingness to pay,  $\pi$  is the solution of  $u(w - \pi) = V_{GHTV}(f)$ , and we find a maximum insurance premium of:

$$\pi_{GHTV} > \left[ \alpha p_{max} + (1-\alpha) \frac{p_{min} + p_{max}}{2} \right] l.$$

Therefore, if  $\alpha > 0$ , the individual lends more weight on  $p_{max}$ : the premium is higher in an imprecise situation than in a precise one, which denotes ambiguity aversion:  $V_{SEU} > V_{GHTV}$  and  $\pi_{SEU} < \pi_{GHTV}$ . If  $\alpha = 1$ , it is an extreme case where the decision maker only takes into account the worst case. If  $\alpha = 0$ , we get back to an SEU representation.

### 2.3 Insurance decision under conflict

Conflict occurs when several experts are consulted to estimate the probability distribution, but they disagree and each gives their

own estimate. Gajdos and Vergnaud (2009) have formalized decisions with conflicting information. They suppose that people exhibit conflict aversion, i.e. that they always prefer an imprecise situation over a conflicting one; they prefer information that is consensual and dislike when it is controversial. Furthermore, they prefer when the experts have opinions that are not too different from one another. Let's consider a decision maker facing conflict from two different experts giving respectively a set of probability distributions  $P$  and  $Q$ . Gajdos and Vergnaud (2009) represent preferences as follows:

$$V_{GV}(f) = \text{Min}_{\gamma \in \Gamma} \left[ \gamma \left( \text{Min}_{p \in \varphi(P)} E_p u(f) \right) + (1 - \gamma) \left( \text{Min}_{p \in \varphi(Q)} E_p u(f) \right) \right]$$

$$\text{with } \Gamma = \left\{ (1 - \lambda)(\frac{1}{2}; \frac{1}{2}) + \lambda(t; 1 - t) \mid t \in [0; 1] \right\}$$

$\varphi$  is a linear mapping representing the subjective treatment of the information,  $\Gamma$  is a symmetric closed and convex subset that represents the attitude toward conflict, and  $\lambda (\lambda \in [0; 1])$  can be interpreted as a measure of conflict aversion. This model allows to take into account both attitudes toward imprecision and conflict, and can be read in two steps. First, the decision maker evaluates experts' assessment via  $\varphi$  and comes up with a belief for each assessment. Second, the evaluations are aggregated via the set  $\Gamma$ .

In our insurance context with conflict, let consider that one expert says that the loss probability is  $p_{min}$ , and the other says it is  $p_{max}$ . There is no imprecise information, i.e.  $P$  and  $Q$  are singletons respectively equal to  $p_{max}$  and  $p_{min}$ . Then, we only minimize on  $\Gamma$ , and the value of decision  $f$  can be written as:

$$\begin{aligned} V_{GV}(f) &= (1 - \lambda) \left[ \frac{1}{2} E_P u(f) + \frac{1}{2} E_Q u(f) \right] + \lambda \text{Min}_{t \in [0; 1]} \left[ t E_P u(f) + (1 - t) E_Q u(f) \right] \\ &= \text{Min}_{t \in [0; 1]} \left[ (\frac{1}{2}(1 - \lambda) + \lambda t) E_P u(f) + (\frac{1}{2}(1 - \lambda) + \lambda(1 - t)) E_Q u(f) \right] \end{aligned}$$

where  $E_P u(f) = p_{max} u(w - l) + (1 - p_{max}) u(w)$  and  $E_Q u(f) = p_{min} u(w - l) + (1 - p_{min}) u(w)$ . The willingness to pay is the solution of  $u(w - \pi) = V_{GV}(f)$ , that is:

$$\pi_{GV} > \left[ \lambda p_{max} + (1 - \lambda) \frac{p_{min} + p_{max}}{2} \right] l.$$

$\lambda$  captures the attitude toward the experts' disagreement. Indeed, it reflects an arbitrage between the actuarial expected loss, which gives the same weight to both possible values of  $p$  and then do not differentiate the experts; and  $p_{max}$ , which allows to differentiate one expert over another.

According to these models of risk, imprecision and conflict, the decision maker should always prefer a precise situation over an imprecise one. Furthermore, he/she should always prefer an imprecise situation over a conflicting one. Therefore, in our survey, the maximum premium the individuals are willing to pay should be the lowest in presence of risk, and it should increase with imprecision and even more with conflict.

### **3. PREDICTIONS AND EXPERIMENTAL DESIGN**

#### **3.1 Main predictions**

The literature on decision making on insurance of extreme events brings to light that individuals behave differently in the presence of risk, imprecision and conflict, that they face difficulties in interpreting small probabilities and do not only reason based on the expected value. Insurance decisions are not yet entirely understood and it is interesting to analyze them by means of a large distributed survey. Considering the effects of ambiguity on insurance decisions dealing with extreme event risks is an important step in the conception of insurance and prevention strategies dealing with these risks.

This paper reports a survey administered to a large representative sample of the French population. Respondents were asked to give the maximum premium they are willing to pay to purchase an insurance contract against a specific low-probability risk. Our main goal is to determine whether there is an insurance demand for ambiguous extreme risks and how the willingness to pay is related to the observable characteristics of the respondents. Let consider the following set of hypotheses, consistent with the theoretical literature.

**H1:** Individuals exhibit risk aversion.

**H1.1:** Their willingness to pay for insurance is greater than the expected loss.

**H1.2:** They prefer the safer option and subscribe to an insurance contract. According to the theory, unless they perceive the probability as null, individuals will always decide to insure and have a positive willingness to pay.

**H2:** Individuals exhibit ambiguity aversion.

**H2.1:** They are willing to pay a higher premium for a risk with ambiguous probability (imprecise or conflicting) than for a comparable risk with precise probability.

**H2.2:** They exhibit growing ambiguity aversion. When the ambiguity gets larger, the willingness to pay for insurance increases.

**H3:** Individuals behave differently according to the ambiguity source: they exhibit conflict aversion.

**H3.1:** They are willing to pay a higher premium for a risk with conflicting probabilities than for a comparable risk with imprecise probability.

**H3.2:** They prefer a consensual information over a controversial one. They find experts as less trustworthy when they disagree.

### 3.2 Motivation and survey questions

The survey is based on Kunreuther et al (1993), Cabantous (2007) and Cabantous et al (2011), but applied to the insurance demand. In these papers, insurers face ambiguous and extreme event risks. They have to indicate if they are willing to underwrite the risks and, if they do, what is the minimum pure premium they would accept to underwrite the risk. In our survey, we ask similar questions to individuals in order to determine the behaviors of insureds. They have to give the maximum pure premium that they would pay to transfer the risk to the insurers. The individuals have to imagine an insurance context in which a risk manager of a big company calls upon two experts in order to determine the true value of the occurrence probability that a windstorm risk would damage their buildings. The information given by the experts can take three forms:

- In a risky situation, the occurrence probability can be precisely estimate. The experts come to a consensus and agree on a unique and precise probability  $p$ .
- In an imprecise situation, it is impossible for the experts to narrow the occurrence probability to a precise estimate. Therefore, the experts agree that the occurrence probability ranges within an interval  $[p_{min} ; p_{max}]$ .
- In a conflicting situation, the experts might not have the same information or hypotheses. Therefore, they disagree and each expert gives their own estimate of the occurrence probability: either  $p_{min}$  or  $p_{max}$ .

In addition, the survey tests for growing imprecision and growing conflict aversion. In that sense, subjects are requested to respond to two other questions related to two other ambiguous situations. In a growing imprecise situation, the experts agree that the probability

range within a larger interval [ $p_{min} - k ; p_{max} + k$ ]. In a growing conflicting situation, the experts disagree and each expert gives their own estimate: either  $p_{min} - k$  or  $p_{max} + k$ .

In order to be able to compare the questions, the precise and consensual estimate of the risky situation ( $p$ ) is the mean<sup>4</sup> of  $p_{min}$  and  $p_{max}$ , and of  $p_{min} - k$  and  $p_{max} + k$ . We assume that the loss amount estimation is not an issue to the experts (100,000€), hence the expected loss is always the same (1,250€). Ultimately, the respondents answer five questions, which are summarized in Table 1, with the complete summary found in the Appendix. After each question, they have the possibility to write a comment in order to explain their choice. These comments will be included in the analysis.

The behaviors under risk and ambiguity can vary depending on the scenario. In addition to the natural risk of windstorm, questions on an environmental liability risk scenario based on de Marcellis (2000) were also asked. This scenario introduces a man-made risk of pollution that could trigger the third-party liability of a company. We used the same probabilities as in the windstorm risk scenario, but with a higher loss amount (2,000,000€), thus the expected value is 25,000€. The questionnaire was divided into three parts. One part contained the windstorm risk scenario and the other part the environmental liability risk scenario. For both these parts, there were ten questions over all. The last part asked about the respondents' characteristics (e.g sex, age, job, level of education, income level, marital status, region of living), insurance (insurance claims in the past three years, amount, type), and extreme events (past experience concerning windstorm and

| <b>TABLE I<br/>THE QUESTIONS</b> |                          |  |
|----------------------------------|--------------------------|--|
| <b>Questions</b>                 | <b>Information type</b>  | <b>Occurrence probability</b>                              |
| <b>1 Risk</b>                    | Consensual and precise   | 1.25%  |
| <b>2 Imprecision</b>             | Consensual and imprecise | Between 0.5% and 2%  |
| <b>3 Growing imprecision</b>     |                          | Between 0.1% and 2.4%                                      |
| <b>4 Conflict</b>                | Conflictual and precise  | 0.5% according to an expert, 2% according to another one   |
| <b>5 Growing conflict</b>        |                          | 0.1% according to an expert, 2.4% according to another one |

pollution risk, perception of the terrorism risk level in their country). The order of the scenarios and the order of the questions inside each scenario were randomized in order to control for potential order effect.

### **3.3 Sampling plan and respondents**

The survey was administered, with the assistance of a marketing institute, through a web-questionnaire. In this way, the experiment took place in a free environment, and individuals can reveal their preferences without constraints. The subjects were compensated with points entitling them to vouchers. There were no other incentives except this flat gain, but we presume that individuals know how they would behave in situations where they have the choice, in particular because the questions have a practical orientation through the insurance context. The survey was completely anonymous, thus the respondents did not have any reason to disguise their preferences.

The questionnaires have been sent to individuals in order to have a final sample matching certain characteristics of the French population. The quotas have been calculated from the 2006 census report of the French National Institute of Statistics (INSEE), on sex, age, regions of France, and socio-economic groups. Experimental papers are usually based on responses from student subjects who have an economic background and therefore they give particular attention to the level of probabilities. However, our experiment is based on a representative sample of the French population. This “real population” does not necessarily have any background in economics or probability, and their responses might not be the same as students. The final sample consisted of 1505 questionnaires. We excluded 33 individuals<sup>5</sup> (2.19% of the sample). The analyzed sample of 1,472 responses still portrays the French population<sup>6</sup>.

## **4. RESULTS**

The literature on insurance decisions suggests that both the insurance decision and the decision of the insurance premium depend on the risks characteristics (occurrence probability and loss amount), the context of the insurance contract, the preferences of individuals, and socio-demographic factors. However the underlying variables are not the same in both decisions. Therefore, in our analysis, we separate the insurance decision per se to the amount of insurance premium, as in the article by Guiso and Jappelli (1998).

## 4.1 The insurance decision and its determinants

### 4.1.1 The impact of ambiguity sources on the decision to insure

We focus here on the insurance decision per se, that is whether people buy insurance or not. Buying insurance is a signal of risk aversion, and refusing insurance reveals a taste for risk in the sense that the individual is willing to accept the whole consequences of the event. Table 2 and Table 3 report respectively the number of refusals for the windstorm and the environmental liability risk scenario. The percentage of individuals refusing to purchase insurance ranges between 25.2% and 31.8% of the sample for the windstorm risk scenario. The other scenario gives similar results. These results go in the opposite direction of hypothesis H1.2 which assumed that it was hard to imagine not buying insurance, even at a low price, considering the large possibility of loss. The refusal to purchase insurance can be explained by the fact that people are risk lover, or because they underestimate the occurrence probability of the risk, believing it is null.

Other explanations were found reading the comments<sup>7</sup> of the respondents, especially the fact that people do not feel concerned about the risk so they do not fear it. Furthermore, an important factor of refusing insurance seems to be related to a lack of trust in the insurance market, and in particular of insurers. Indeed, lots of negative comments reveal that individuals dislike insurance companies and they do not trust the will of insurers to pay claims. Some people wrote comments explaining that insurers intentionally overestimate occurrence probability in order to ask for higher premiums. Other comments complained about how insurers do not pay back as much as they promised once the risk occurs. Therefore, the insurance industry seems to be perceived negatively in France.

Moreover, the refusals grow with ambiguity. The percentage of respondents not buying insurance increases in the imprecise situation and even more in the situation of growing imprecision for both scenarios. This progression of refusals is even stronger with conflict, and reaches almost one third of the sample with growing conflict. Therefore, people seem to dislike ambiguity in insurance and refuse to insure. They seem to place more credence on  $p_{min}$  and  $p_{min} - k$ , considering these low estimates as null. Indeed, people are more willing to trust the expert expressing almost certainty (an estimate close to 0) than the one expressing more riskiness (Baillon et al, 2011). This is also linked to the problem of confidence in insurance markets. People prefer taking the risk thinking the probability is null, rather than purchasing insurance and trusting experts who may be wrong. This rejection of

experts' estimates is greater in conflict than in imprecision, which confirms hypothesis H3.2 that people prefer consensual information and tend to avoid conflicts.

#### **4.1.2 The impact of observable characteristics on the decision to insure**

Observable characteristics influence the decision to insure. When running independence tests (chi2 tests), several variables appear to be significant. The individuals refusing insurance are mostly the youth. Between 18 and 25 years old, 30% do not buy insurance in comparison to 19% for the more than 50. The number of refusals is higher for the lower socio-economic groups<sup>8</sup>, those persons with little or no level of higher education, those with low incomes and bachelors. Furthermore, more people are willing to insure if they have claimed on insurance damage within the last three years, and if they or their neighbors have experienced a windstorm event in the past. Finally, the majority of the respondents that criticized the insurers would not buy insurance.

In Table 4 of Appendix B, we report the Probit estimates of the binary decision of buying insurance or not for the windstorm risk scenario<sup>9</sup> with the marginal effects on each variable. The probability of buying insurance positively depends on age and on education level. Being between 25 and 49 years old, in comparison with the youngest, increases the probability to insure by 23%. Being older than 50 increases the probability to insure by 32%. In terms of marginal effect, the predicted probability of buying insurance is 7% for the 25-49 and 9% for people older than 50. In addition, having a higher degree (Masters degree or Ph.D.) increases the probability of purchasing insurance by 30% in comparison to having no degree. People with higher education are more willing to insure than people with less education. One could think that it is related to the level of income; however income is not a significant variable in the insurance decision. According to Kunreuther (1984), refusing insurance cannot be explained by income, but more by the deny of the exposure to extreme events. In this way, the Probit estimates show that past experience<sup>10</sup> with windstorms has a significant positive effect on the demand for insurance. In addition, the people that claimed on insurance damage within the last three years are also more willing to buy insurance. These variables are related to the regions of France, the north being more impacted by windstorms than the south. Then, the demand for insurance is higher for residents in this part of France. Finally, the perception of the terrorism risk is a significant factor on the insurance decision. This variable should not have a great impact as it is related to the formation of beliefs and not to information processing.



**TABLE 2  
SUMMARY STATISTICS OF THE WINDSTORM RISK  
SCENARIO**

|                    | <b>Risk</b> | <b>Impre-<br/>cision</b> | <b>Growing<br/>impre-<br/>cision</b> | <b>Conflict</b> | <b>Growing<br/>conflict</b> |
|--------------------|-------------|--------------------------|--------------------------------------|-----------------|-----------------------------|
| Nb of refusals     | 377         | 386                      | 422                                  | 404             | 468                         |
| % of refusals      | 25.5%       | 26.2%                    | 28.7%                                | 27.4%           | 31.8%                       |
| Mean<br>premium(€) | 1 920       | 1 632                    | 1 846                                | 1 763           | 1 709                       |
| Mean/EL            | 1.54        | 1.31                     | 1.48                                 | 1.41            | 1.37                        |

Note: EL means Expected Loss, defined as the average probability multiplied by the total loss amount: EL=1,250€, 1.25% chance of losing 100 000€.

**TABLE 3  
SUMMARY STATISTICS OF THE ENVIRONMENTAL  
LIABILITY RISK SCENARIO**

|                    | <b>Risk</b> | <b>Impre-<br/>cision</b> | <b>Growing<br/>impre-<br/>cision</b> | <b>Conflict</b> | <b>Growing<br/>conflict</b> |
|--------------------|-------------|--------------------------|--------------------------------------|-----------------|-----------------------------|
| Nb of refusals     | 325         | 330                      | 374                                  | 331             | 437                         |
| % of refusals      | 22.1%       | 22.4%                    | 25.4%                                | 22.5%           | 29.7%                       |
| Mean<br>premium(€) | 14 625      | 14 726                   | 15 374                               | 14 176          | 13 517                      |
| Mean/EL            | 0.58        | 0.59                     | 0.61                                 | 0.57            | 0.54                        |

Note: EL=25,000€: 1.25% chance of losing 2,000,000€.

To summarize, it is possible to find a set of characteristic variables that helps to understand the insurance decision. That decision is not only an arbitrage toward the risk specificities. Refusing insurance reveals a lack of confidence in the French insurance industry, a result that might not be the same in other countries where the risk culture is different. The socio-economic characteristics (age, level of education), as well as the experience in terms of insurance and extreme risk events, significantly impact the decision to insure. However, we will see in the next section that the factors are not the same for the willingness to pay, which seems to be a heterogeneous decision.

## 4.2 The insurance willingness to pay and its determinants

### 4.2.1 People behave differently in practice compared to theory

We focus here on the willingness to pay for insurance, i.e. on insurance amounts people are willing to pay for insuring against specific risks, and in particular on the behaviors in the windstorm risk scenario<sup>11</sup>. Table 2 reports the means of premium and of normalized premium of the respondents buying insurance<sup>12</sup>. A normalized premium equal to one denotes an insurance premium equal to the expected loss, and then a risk neutral attitude. We see that premiums are significantly higher than the expected loss for the five questions. This fact corroborates hypothesis H1.1 that people exhibit risk aversion. The premium distribution shows a strong asymmetry to the left, the skewness being on average around 6.20. Almost 70% of the population buying insurance is willing to pay a premium lower than 1,000€, i.e. 0.8 in terms of expected loss. This taste for risk of certain respondents might be the consequence of misunderstanding risk characteristics or the importance of other factors. People do not only take a decision based on probability. Indeed, some people have indicated in the comments that they are not familiar with probabilities. Previous studies have been conducted on student subjects who had greater familiarity with probability.

The results show that the mean premium with precise information is always greater than the one with imprecise or conflicting information. Student tests<sup>13</sup> confirm that these results are robust. Therefore, H2.1 is rejected because people exhibit ambiguity seeking behaviors: they are willing to pay a higher price in situation of risk than in situation of ambiguity. This finding does not go in the sense of the usual literature supposing ambiguity aversion in low probability losses. However, the popular hypothesis of ambiguity aversion has met some mixed validations. Several empirical evidences suggest that ambiguity preference in low probability losses exists (Einhorn and Hogarth, 1986; Cohen et al, 1987; Dobbs, 1991; Kuhn, 1997; Ho et al, 2002; Chakravarty and Roy, 2009; Wakker, 2010, on page 354;...). Therefore, it is not clear yet how people respond to ambiguity in losses. In particular, Sarin and Weber (1993) study the effect of ambiguity on the price in market experiments, and find that the price for ambiguous assets is lower than the price for unambiguous assets. They explain it by the fact that subjects consider an ambiguous asset as inferior, and thus they are willing to pay less for it. Within an insurance context, Wakker et al (2007) find ambiguity seeking in the willingness to take insurance, because people prefer the more familiar option and that normal decisions are made without extra statistical information.

The contexts of growing ambiguity lead to different results. Regarding the attitudes toward imprecision, the mean premium increases in the situation of growing imprecision. People are willing to pay a higher price when the interval of probability gets larger<sup>14</sup>. Therefore, they exhibit growing imprecision aversion, which confirms hypothesis H2.2. However, regarding the attitudes toward conflict, the mean premium in situation of conflict is higher than the one in situation of growing conflict. Therefore, people exhibit a certain taste for growing conflict<sup>15</sup>. The two situations of conflict have been clearly seen as different, given the number of refusals (see previous section). Hypothesis H3 suggests that the attitudes toward imprecision and conflict are different. The results show that the mean premium with imprecise information is significantly lower than the one with conflicting information. Thus, hypothesis H3.1 is confirmed. However, the opposite is true between growing imprecision and growing conflict even if the difference is not statistically significant. The weight given to the lowest estimate is higher in a situation of growing conflict than in a situation of growing imprecision (Baillon et al, 2011). People behave in different ways in the presence of conflict and imprecision. The differences between the five questions are robust within the sample. We tested several subgroups with specific characteristics to determine if one subgroup had completed the whole set of hypotheses cited in section 3.1. We found similar results within each group.

Concerning the environmental liability scenario, the results are very different (see Table 3). Surprisingly, the mean premiums are always lower than the expected loss: people exhibit a taste for risk. Nearly 90% of the sample are willing to pay a premium lower than the expected loss. The rank of the questions is almost the same as for the windstorm risk scenario, except that the mean premium under risk is on the same level as the mean premium of the other questions. The premium distribution is much smoother, and the differences between the questions are not as significant<sup>16</sup>. Kunreuther et al (1993) underline the fact that the premiums are different depending on the scenario. The differences can be explained by a misunderstanding of the scenario. People face difficulties to assess a risk with a total loss amount of 2 billion euros. Furthermore, they cannot easily imagine an environmental risk, which is less common and more specific to companies. A windstorm risk is much easier to imagine. Finally, it may have behavioral differences between a natural risk of catastrophe and a man-made risk of pollution.

#### **4.2.2 The impact of observable characteristics on the willingness to pay**

The insurance premium decision seems to be correlated to observable characteristics, according to independence tests ( $\chi^2$ ) and analyses of variance (ANOVA). Especially, women are willing to pay on average a premium 25% higher than men. The premiums are also higher for the youth (less than 25 years old), the low socio-economic groups and the low incomes. In addition, individuals feeling the terrorism risk at a high level are willing to pay on average 2,400€ (1.9 in terms of expected loss); and the ones feeling that the terrorism risk is very low are willing to pay on average 1,000€ (0.8 in terms of expected loss). Regarding comments, the respondent criticizing insurance markets are willing to pay a very low premium (on average 220€, i.e. 0.18 in terms of expected loss).

Due to the censoring of the variable (refusals of insurance being premiums equal to 0), we ran a Tobit<sup>17</sup> model on the whole insurance demand decision. However, the sign pattern and statistical significance do not match those of the Probit model. Only two characteristics have a significant and positive influence on insurance demand on the whole: the fact that people have reported an insurance claims within the last three years, and the level of perception of terrorism risk. With only two significant variables, the insurance demand cannot be explained by observable characteristics. However, the Tobit model is an ordered regression and does not represent bimodality. Indeed, there could be a bimodality for a certain number of individuals<sup>18</sup>. Other models are needed to translate this possible effect. Nevertheless, it is not possible to find a set of significant variables explaining the level of insurance premium. Within an insurance context, there seems to be several attitudes toward risk, imprecision and conflict.

### **4.3 General discussion**

#### **4.3.1 The insurance demand differs according to the information type**

This paper separates the decision to insure and the level of the willingness to pay. In the decision to insure, one third of the population is willing to take the consequences of a low-probability event and does not buy insurance. This decision can be explained by the respondents' observable characteristics and by a lack of confidence in the insurance industry. In the decision of the insurance premium, people exhibit risk

aversion (Kunreuther, 1978; McClelland, Schulze, and Coursey, 1993) and ambiguity seeking behaviors (Sarin and Weber, 1993; Wakker et al, 2007). In addition, the attitudes toward imprecision and conflict are different. They pay a higher premium in the situation where experts disagree, however fewer people are willing to insure. People exhibit conflict aversion, they prefer consensual information and deeply dislike conflicting one.

Smithson (1999) and Cabantous et al (2011) explain that people attribute imprecision to the task difficulty and conflict to the incompetence of the experts. The differences between these two ambiguity sources can come from the unknown and unknowable informations of Chow and Sarin (2002)<sup>19</sup>. Here, imprecision is related to the unknowable information and conflict to the unknown information. Chow and Sarin (2002) find that people prefer when probabilities are precise (known information) and they feel insecure when they are ambiguous (unknown information), because they think someone else possesses the information. This feeling of relative ignorance can be found in the higher number of refusals in the presence of conflict. Furthermore, they prefer unknowable information over unknown information. According to them, uncertainty is more acceptable when the information is not available at all. In this sense, it can explain why people prefer imprecise information (unknowable) over conflicting one (unknown). Meanwhile, known information is always preferred. That is why people are willing to pay a higher premium under risk. They consider ambiguous situations as being inferior (Sarin and Weber, 1993).

With controversial information, people think that the disagreement is due to the expert's incompetence, or to the insurer's will to increase premiums (linked to the negative perception of insurance in France). The competence of an expert is related to their credibility. In the questionnaire, respondents had no information that could allow to differentiate the experts. Even in real life, the reliability of expert opinion is difficult to assess and decisions contain subjectivity. The behaviors and choices depend on the perceived reliability of the available information. This perception can change when conflict grows. Therefore, the expert almost claiming certainty (an occurrence probability almost equal to zero) could be preferred and outweighed in the decision (Baillon et al, 2011).

#### **4.3.2 The insurance demand varies depending on the context**

The results reveal different attitudes according to the scenario. Respondents are willing to pay greater premium than the expected loss facing a windstorm risk, but a much lower one facing an environmental

risk. Kahn and Sarin (1988) report that the context causes subjects in a consumer choice experiment to switch from being ambiguity averse to ambiguity seeking. For insurers, the type of peril also seems to affect the decision. Insurers charge higher premiums for earthquake and hurricane risks than for pollution and fire risks (Cabantous, 2007; Cabantous et al, 2011). In our results, the differences can be linked to behavioral differences due to the peril type (natural risk versus man-made risk), and/or to the larger total loss amount of the environmental risk that has been underestimated.

In the comments, some individuals explicitly wrote that they will never face the environmental liability risk. Indeed, the risk of pollution is mostly relevant to companies. The scenario is highly hypothetical for individuals, and therefore individuals were requested to act in the capacity of a company. In this way, they do not only reason based on their own possible risks. Moreover, the problem of competence is much deeper, as comments reveal that they do not want to take the responsibility for that kind of decision. They prefer government intervention in case of extreme risks. Thinking about extreme risks is difficult and believing the consequences takes a cognitive effort. Appreciating such biases and reducing them through prevention and communication, is an important step.

#### **4.3.3 The insurance demand is influenced by other factors**

People do not only reason based on the risk characteristics. The general public constituent our sample does not necessarily understand probabilities and high amounts of losses. Some admit in the comments of not having any background in mathematics. People cannot always make an explicit trade-off between the expected benefits of buying insurance and the possible costs of taking the risk (Kahneman and Tversky, 2000). Furthermore, the presence of ambiguity makes it more difficult to arbitrate, leading to either overestimating or ignoring small probabilities (Kunreuther et al, 2001). People face difficulties assessing an equivalence between ambiguous and non-ambiguous probabilities, or believing a very large amount of loss. The available information is misunderstood.

Behaviors are affected by risk perception, itself distorted by cognitive biases and emotional factors such as pessimism and myopia. Especially, the level of perception of the terrorism risk is always a significant variable. However, it is related to the formation of beliefs and not to the objective analysis of the available information. This variable represents, in our survey, a proxy for pessimism and thus ambiguity aversion. Indeed, it depicts a constant psychological trait on different

decisions. Furthermore, past experience concerning the risk is also a significant variable, in particular to the decision to insure. People often purchase insurance following a disaster. They do not think that the best return on an insurance policy is no return at all. Most individuals consider that the event will simply not happen to them. It is a psychological bias toward short-term maximization instead of long-term planning (myopia). In addition, in France, catastrophe coverage is usually automatically included in a comprehensive home insurance contract (without even people knowing about it); and the government helps in case of major event. Then, the status quo is not changing its insurance coverage. Therefore, insurance decisions represent a balance between intuition and more deliberate analysis.

The insurers' reputation appears to be an important factor of the insurance decision. Comments reveal a lack of trust in the insurance industry. People do not insure because they think that the insurers will not reimburse them in case of a loss event. However, this belief seems false. Indeed, the results also show that more people buy insurance when they have reported insurance claims than when they have not. The people dealing with insurance are more willing to insure and to buy insurance at higher premiums. Therefore, there seems to be a difficulty to trust insurers before experiencing an insured loss.

## **5. CONCLUSION**

Of particular interest here is whether the insurance decision is fundamentally different for precise, imprecise and controversial extreme events, and whether it is possible to find some determinants of insurance demand through a survey administered to a large representative sample of the French population. Our results provide the evidence that individuals as non-sophisticated subjects of the insurance markets behave in ways that do not go in the sense of decision theory. Two decisions are differentiated: the insurance decision per se and the willingness to pay. On the one hand, almost one third of the population is not ready to take insurance and that decision is impacted by the socio-demographic characteristics of the respondents and by the degree of trust they have in the insurance industry. On the other hand, the individuals asking for insurance exhibit risk aversion and ambiguity seeking behaviors. In situations of risk, individuals feel comfortable and trust the experts. In situations of ambiguity, they raise doubts because of the difficulty to assess low probability events or to trust experts that might be wrong. They consider ambiguous situations as inferior and are not willing to pay so much for them. Furthermore they

exhibit conflict aversion and always prefer a consensual information in which the information is unknowable. They dislike controversial situations because they feel insecure in trusting one expert over the other. Then, the risk characteristics, the information type, the context, the beliefs and the personal characteristics affect the decision-making process of insurance demand.

On the demand side, people exhibit risk aversion, they are willing to pay a higher premium than the expected loss, but the premium they are willing to pay decreases in situations of ambiguity (imprecision and conflict). However, on the supply side, previous studies have shown that insurers are slightly risk averse but strongly increase the premiums in situations of ambiguity (Cabantous, 2007; Cabantous et al, 2011). In a free market, supply has to meet demand. Therefore, an insurance market for extreme events, where the risk characteristics are precise, can exist, but it seems that there is no possibility for a free market for extreme events where the risk characteristics are ambiguous. In that sense, Einhorn and Hogarth (1986) reveal that sellers of insurance exhibit more ambiguity aversion than buyers of insurance. Indeed, the agent who supports the risk gives more attention to loss amounts because a misunderstanding of the probabilities can lead to severe consequences. Furthermore, the buyer always wants the lowest price and is more ready to trust the lowest estimates. In order to have a market for extreme and ambiguous risks, it is important that insureds and insurers have similar view of the risk characteristics. Therefore, communication on the risks has to be improved. An alternative solution is that of government intervention, through public-private partnerships or by making insurance for extreme risks compulsory.

These results point to a panel of recommendations concerning the communication of insurance companies. The first of them would be for insurers not to communicate in the same manner according to the risks and to the available information. Insurance companies should provide both qualitative and quantitative information. In order to avoid a priori judgments on certain risks and to encourage people to buy insurance, it would be useful to present the risks as being of personal concern to the potential buyers. Indeed, the results show a strong difference in the way in which individuals manage catastrophic and man-made events. People think they can handle their own attitude towards risk. Another recommendation deals with the reputation of insurance companies—an issue that has to be taken seriously. In the comments, respondents wrote that insurers manipulate data. Insurers should thus be very transparent in their communication, and straightforward in what regards premiums. The products should be presented in a realistic way. Consumers tend to prefer an imprecise piece of information when experts openly



define it as unknowable. They do not want insurers to lie to them or to overload them with information. Therefore, it is important to recognize that there are uncertainties surrounding extreme risks. Furthermore, the reputation of insurance companies seems to improve once people have actually dealt with insurers. It is then essential to develop and secure the loyalty of the clients. It could hence be interesting to consider the way in which people think of insurers according to whether the insurance claims have been paid or have only been reported without having given right to a refund.

A limitation of this survey could be that the questions asked are abstract; connected to rare events and hypothetical situations. Nevertheless, this survey is part of a global project on decision making. We are currently running surveys dedicated to insurance professionals (insurers and reinsurers), in order to have a global assessment of the insurance market for extreme and ambiguous event risks. The project will provide insights on behaviors in the insurance markets.

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## Notes

1. The subjects were provided with a probability and were told that this was the best estimate available.

2. With  $\alpha$ MaxMinEU preferences,  $V_{\alpha\text{MaxMinEU}}(f) = \alpha[p_{\max} u(w-l) + (1-p_{\max}) u(w)] + (1-\alpha)[p_{\min} u(w-l) + (1-p_{\min}) u(w)]$ , and therefore the maximum insurance premium the decision maker is willing to pay is  $\pi > [\alpha p_{\max} + (1-\alpha) p_{\min}] l$ , where  $\alpha$  represents the attitude towards ambiguity.

3. If the decision maker has a set of beliefs  $q_i$  over  $P$ : For  $q_i \in [0; 1]$  and  $p_i \in [p_{\min}; p_{\max}]$ ,  $V_{20B}(f) = \sum q_i \Phi(\sum p_i (p_i u(w-l) + (1-p_i) u(w)))$  and  $V_{20B}(g) = \Phi(u(w-\pi))$ . Therefore,  $\pi > [\sum q_i \sum p_i q_i p_i] l$ .

4. Contrary to Cabantous et al (2011), we use the arithmetic mean and not the geometric mean. In their paper, they use  $p$  equal to 1%, the geometric mean of  $p_{\min} = 0.5\%$  and  $p_{\max} = 2\%$ .

5. These are individuals explicitly demanding not to analyze their responses because they did not know how to answer (4 individuals), or they are individuals willing to pay a premium greater than the highest possible loss (29 individuals), revealing an obvious misunderstanding or misreading of the questions.

6. Of the 1472 respondents, 49% were male and 51% females. The youth (between 18 and 24) represent 14% of the population. The 20-34 and the 35-49 year olds account respectively for 22% and 34% of the population, the 50-59 for 21% and the 60-65 for 9%.

7. In the survey, 30% of the respondents wrote comments that we divided into four qualitative categories: the one finding the survey interesting and being enthusiastic, the one giving neutral opinions or suggestions, the one finding the survey difficult, and the one criticizing insurance markets.

8. The socio economic groups can be divided into two main groups: an upper group that is supposed to have a high purchasing power, and a lower group with poor purchasing power.

9. The Probit estimates of the environmental liability risk scenario are not presented as the results were similar but less significant than the ones of the windstorm risk scenario.

10. The fact that the respondent or its neighbors and family have experienced a risk of windstorm.

11. As we will see later, the results of the windstorm risk scenario are more robust and more significant than the ones in the environmental liability scenario.

12. These premiums are calculated based on the respondents buying insurance, and then the samples are not exactly the same. However, taking the same sample reduce the number of observations and produces exactly the same results.

13. The p-values of the t-tests on the differences between risk and imprecision or conflict are null.

14. The p-value of the t-test on the difference between imprecision and growing imprecision is 0.062.

15. However, the Student test on the mean difference between conflict and growing conflict is not significant (p-value of 0.135), but the test on the median difference is significant (p-value of 0.007).

16. The Student tests show weaker differences between the questions.

17. The results of the Tobit model are not presented in this paper due to their poor significance.

18. The people refusing insurance and the people demanding the highest premiums seem to have similar characteristics (youth, low socio-economic group, and low income).

19. Chow and Sarin (2002) differentiate known, unknown and unknowable information. Known information refers to a precise situation. Unknown information refers to an ambiguous situation for which other people might have the missing information. Unknowable information refers to an ambiguous situation in which nobody knows the true value of the missing information.

## APPENDIX A: SURVEY ON INSURANCE DEMAND

### *Short instructions before starting:*

First of all, thank you for participating to this survey dealing with understanding insurance behaviors. It consists in a scientific study about the decision making process of individuals working in insurance. This research is sponsored by the University Paris 1 Panthéon-Sorbonne and will provide support for a PhD in Economics. Completing this survey will take between 12 and 15 minutes depending on your answers. The objective is to analyze how individuals make decisions in situations of risk that may be encountered in professional life. You should consider the hypothetical situations as real life situations. Some situations presented may seem extreme or unrealistic. What is interesting is your decision given the situation. There is no right or wrong answer. This survey is completely anonymous. The survey results will be published in a consolidated form only. If you wish to receive them once it is completed, you can leave your email address. Please read the instructions carefully and answer as honestly as possible. Thank you in advance for your participation.

*Functioning of insurance:* The policyholder transfers a risk (random by definition) to the insurance company. The insurance company accepts the risk in exchange for an insurance premium. The policyholder is then protected against covered events that he/she does not want to support solely. The insurance mechanism does not modify the occurrence probability of the risk and its consequences. The insurance company realizes a risk mutualization between the insureds through the underwriting of numerous similar risks. This risk management allows the insurer to pay off all the disasters which the insureds will undergo using the premiums paid up front.

*Your role:* You are the Head of Risk Management in a large company which owns several buildings. You are in charge of defining insurance contracts that you are willing to buy in order to protect the company against some particular risks. In other words, you choose the insurance coverage against losses linked to potential risks. The purpose is here to analyze the risks of the different buildings in order to cover them separately. Two types of risks can exist: A windstorm risk and an environmental liability risk.

### *Two risk characteristics*

- The total loss amount: In case of a windstorm risk, it includes direct insured losses (destruction of buildings, contents) and business interruption following the disaster, estimated from the turnover of

the company, net deductibles. In case of an environmental liability risk, the total losses amount includes the material and immaterial damages caused to third parties and the clean-up costs.

- The annual occurrence probability of a risk: X% (i.e. 1 every Y years in average).

*Experts' opinion:* In order to have a more accurate vision of the risk, you have engaged two experts. Based on the company business and on modeling software, they estimate the annual occurrence probability of the risk (windstorm or environmental liability). The assessment of the loss amount does not cause any trouble to the experts. Three cases can come out:

- The experts are in agreement; they have a precise idea of the risk and give a unique probability.
- The experts are in agreement, but they face difficulties in estimating precisely the risk and give an inaccurate estimate of the probability.
- The experts disagree on the estimate, and each expert gives their own probability.

*Your mission:* For each outlined situation, as Head of Risk Management in a large company, you will have to determine the maximum amount of the insurance premium that you are willing to pay in order to cover a risk entirely. The insurance will guarantee you an integral reimbursement in case of a risk. However, you will always have the possibility of refusing to take insurance. In that case, your company will bear the entire loss in case of a risk occurrence. After each answer, you may write a comment. For example, you can explain how you have settled the premium amount, why you have refused to cover the risk, or under which conditions you would change your mind.

### Windstorm risk scenario

In this list of 5 questions, your company is looking for insuring against the windstorm risk. Your company owns several buildings spread in different areas. The risk intensity can vary depending on the vulnerability, the exposure, the safety measures, etc.

*I-Question with risk:* Your experts agree on a unique probability. They estimate that the occurrence probability of a windstorm is 1.25% (i.e. 1 event every 80 years). The total loss amount for the event would be 100,000€. What is the maximum insurance premium that you are willing to pay in order to protect yourself against this risk during one year (write 0€ if you refuse to take insurance)? Do you have any comments?

*2–Question with imprecision:* Your experts agree on an interval for the probability. They estimate that the occurrence probability of a windstorm is between 0.5% (i.e. 1 event every 200 years) and 2% (i.e. 1 event every 50 years). The total loss amount for the event would be 100,000€. What is the maximum insurance premium that you are willing to pay in order to protect yourself against this risk during one year (write 0€ if you refuse to take insurance)? Do you have any comments?

*3–Question with growing imprecision:* Your experts agree on an interval for the probability. They estimate that the occurrence probability of a windstorm is between 0.1% (i.e. 1 event every 1,000 years) and 2.4% (i.e. 1 event every 42 years). The total loss amount for the event would be 100,000€. What is the maximum insurance premium that you are willing to pay in order to protect yourself against this risk during one year (write 0€ if you refuse to take insurance)? Do you have any comments?

*4–Question with conflict:* Your experts disagree on the probability and they provide two different estimations of the probability. One expert estimates that the occurrence probability of a windstorm is 0.5% (i.e. 1 event every 200 years), the other expert estimates that it is 2% (i.e. 1 event every 50 years). The total loss amount for the event would be 100,000€. What is the maximum insurance premium that you are willing to pay in order to protect yourself against this risk during one year (write 0€ if you refuse to take insurance)? Do you have any comments?

*5–Question with growing conflict:* Your experts disagree on the probability and they provide two different estimates of the probability. One expert estimates that the occurrence probability of a windstorm is 0.1% (i.e. 1 event every 1,000 years), the other expert estimates that it is 2.4% (i.e. 1 event every 42 years). The total loss amount for the event would be 100,000€. What is the maximum insurance premium that you are willing to pay in order to protect yourself against this risk during one year (write 0€ if you refuse to take insurance)? Do you have any comments?

#### *Environmental liability risk scenario*

In this list of five questions, your company uses toxic chemical products in the production process and is looking for insurance against the environmental liability risk. Your company owns several buildings and respects the legal norms concerning dangerous product use. However, there is a risk that a leak breaks out and toxic products pollute the neighborhood soil.

*Questions:* The same five questions as in the windstorm risk scenario, but with a total loss amount of 2 billion €.

### Other questions

*Socio-demographic questions:* sex, birth date, region of living, marital status, number of children, socio-economic group, income level.

#### *Insurance questions:*

- Did you report a claim to your insurance company during the last 3 years?
- What was the type of risk?
- What was the approximate cost of the claim? *Extreme event questions:*
- Have you, or one of your relatives or friends, suffered losses due to a windstorm?
- Do you think it has changed your perception on windstorm insurance?
- Have you, or one of your relatives or friends, suffered losses due to an environmental pollution caused by a company?
- Do you think it has changed your perception on environmental liability insurance?
- How high do you consider the risk of terrorism is in your country?

*Suggestions:* Do you have suggestions or comments about this survey? If you want to receive the survey results, please indicate your email address.



## APPENDIX B: PROBIT ANALYSIS

**TABLE 4**  
**THE EFFECTS OF SOCIO-DEMOGRAPHIC CHARACTERISTICS ON THE INSURANCE DECISION IN THE WINDSTORM RISK SCENARIO: PROBIT ESTIMATES**

|   | Coefficient | t-stat | P > t | Marginal probability (%) |
|---|-------------|--------|-------|--------------------------|
| <b>Gender (F → M)</b>                       | -0.025      | -0.30  | 0,767 | -0.689                   |
| <b>Age (&lt;25 years old)</b>               | 0.231*      | 1.77   | 0.076 | 7.054                    |
| 25-49 years old                             | 0.317**     | 2.12   | 0.034 | 9.396                    |
| <b>Socio-economic group (Low)</b>           |             |        |       |                          |
| High  | 0.069       | 0.71   | 0.475 | 1.953                    |
| <b>Degree (No education)</b>                |             |        |       |                          |
| A-level                                     | 0.075       | 0.66   | 0.509 | 2.240                    |
| Bachelor degree                             | 0.168       | 1.52   | 0.130 | 4.880                    |
| Master degree or Ph.D.                      | 0.298**     | 2.06   | 0.040 | 8.247                    |
| <b>Income level (Low: &lt;1600€)</b>        |             |        |       |                          |
| Medium: 1600€- 7600€                        | 0.107       | 1.05   | 0.296 | 3.087                    |
| High: >7600€                                | 0.174       | 0.98   | 0.328 | 4.905                    |
| <b>Marital status (Bachelor)</b>            |             |        |       |                          |
| Common life                                 | 0.014       | 0.11   | 0.911 | 0.395                    |
| Married                                     | -0.044      | -0.34  | 0.731 | -1.273                   |
| Separated or divorced                       | 0.196       | 1.11   | 0.269 | 5.115                    |
| <b>Number of children (0)</b>               |             |        |       |                          |
| 1   | 0.039       | 0.32   | 0.748 | 1.052                    |
| 2 and more                                  | -0.088      | -0.82  | 0.412 | -2.500                   |
| <b>Region of France (South-West)</b>        |             |        |       |                          |
| South-East                                  | 0.222       | 1.59   | 0.113 | 6.685                    |
| Ile de France (region of Paris)             | 0.143       | 0.96   | 0.338 | 4.420                    |
| North-West                                  | 0.290**     | 2.06   | 0.040 | 8.525                    |
| North-East                                  | 0.256*      | 1.81   | 0.070 | 7.613                    |
| <b>Insurance claim</b>                      | 0.266***    | 2.72   | 0.006 | 7.502                    |
| <b>Experience in windstorm risk</b>         | 0.271***    | 2.63   | 0.009 | 7.621                    |
| <b>Experience in environmental risk</b>     | -0.237      | -1.07  | 0.284 | -6.665                   |
| <b>Perception of the level of terrorism</b> | 0.151*      | 1.88   | 0.060 | 4.248                    |
| <i>Constant</i>                             | -0.516      | -1.48  | 0.139 |                          |
| R2  | 0.0384      |        |       |                          |

Note: Marginal probabilities refer to the probability of buying insurance. It gives the predicted probability at each level of the observable characteristics, holding all other variables in the model at their means.