

**Protecting Against Low Probability Disasters:  
A Large Stakes Experiment**

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# Protecting Against Low Probability Disasters

## A Large Stakes Experiment

### Abstract

This paper provides an explanation as to why some individuals purchase insurance against low-probability high consequence events while others choose to be unprotected. Through a controlled experiment with large amounts of money at stake, we show that insurance behavior can be characterized by a two-stage process. In Stage 1 individuals decide whether to consider purchasing insurance. Those who consider this option determine the maximum they are willing to pay (WTP) for protection (Stage 2). Using construal level theory, the relevance of a risk is determined by viewing it from a large psychological distance (Stage 1--*participation*). Those who deem the risk to be worth considering then view it from a smaller psychological distance so that technical details such as probabilities come into play (Stage 2--*spending*). Using data from a controlled experiment with high monetary stakes, a panel econometric analysis reveals that the anticipatory emotion *concern* is the only variable that influences decisions in Stages 1 and 2. Probabilities play a role only in Stage 2. Under conditions of ambiguity, probabilities are largely overestimated so that WTP is considerably higher than when the likelihood of a disaster is well-specified. Our findings can explain why individuals do not purchase insurance voluntarily even when it is highly subsidized as has been observed with respect to flood insurance in the United States. In such cases required insurance may be a more desirable alternative.

## A – Introduction

Insurance decisions against low-probability disasters have been a puzzle to economists and other social scientists since Kunreuther et al.'s (1978) field studies and Slovic et al.'s (1978) controlled laboratory experiments revealed that individuals would not voluntarily purchase coverage even when premiums were highly subsidized. In a controlled experiment that was consistent with these studies, McClelland et al. (1993) showed that most individuals are either not willing to pay a penny for low-probability insurance or are willing to pay far too much when compared with the expected loss from the event.

In this paper we show that such a behavioral pattern is consistent with a two-stage process: one first decides whether to purchase insurance. Stage 1 is labeled *participation*. Those who have a positive willingness to pay (WTP), then determine their maximum WTP for coverage. Stage 2 is labeled *spending*. These two stages in the decision process utilize *different psychological distances* with respect to the potential disaster.

According to construal level theory (Trope and Liberman 2003; Bar-Anan et al. 2006), differences in psychological distance (see also Lewin 1951) have an effect on the attributes relevant for the different parts of the decision. Using a high-stakes experimental study and applying a panel econometrics threshold model, we demonstrate that the determinants of the two stages of the decision are indeed different and that the differences are consistent with what construal level theory would expect for decisions that are made in some distance from the object in question (i.e. *participation*) or in close proximity to the object (i.e. *spending*). In the context of insurance decisions, loss probabilities are expected to be only relevant in the *spending* stage of the decision and we are able to empirically support this prediction.

In our experiment, the probabilities of a loss are extremely low and the potential loss is significant (i.e., \$1,300). To the best of our knowledge, an experiment involving the possibility of losing large stakes has not been previously conducted. Probabilities are either specified precisely (i.e. 1 in 10,000) or there is considerable ambiguity regarding the likelihood of the disaster occurring. Ambiguity is implemented by making the probability of a loss dependent on the number of rainy days in a particular city during a prespecified future time period. The exact probability of such an event is, however, unknown to the subjects. In examining individuals decision processes, we measure the degree of concern with suffering a loss when probabilities are precise and ambiguous as well as the estimate of subjective probability when the probability is ambiguous.

The remainder of the paper is organized as follows. Section B specifies our theory of how protective decisions against low-probability disasters are made based on a two-stage model and construal-level theory. Section C describes the experimental design. The results and the econometric analyses of the data are reported in Section D. Section E discusses the meaning of the key findings and the concluding section F outlines prescriptive implications and future research directions.

## **B – A psychological account of protective decision making**

Each individual faces numerous low-probability risks on a daily basis: car accidents, elevator breakdowns, severe virus infections, becoming the victim of a crime, being hit by lightning, suffering property losses from natural or technological disasters, etc. There are reasons why nobody should be advised or actually deals with all these risks. Kunreuther and Pauly (2003), for instance, state that individuals might maximize expected utility by avoiding the

explicit or implicit cost of searching for the probability of some rare events. But even without information or transaction costs, there are disadvantages in dealing with all kinds of possible disasters such as losing peace of mind by becoming worried or anxious (Baron et al. 2000; see also Loewenstein et al. 2001).

From a psychological perspective, one might expect people to first look at the numerous possible risks *from a distance* and only *zoom in* those risks that pass their threshold of relevance or concern. Empirical evidence for such a process occurring would be consistent with following two hypotheses.

*H1: Protective decisions against low-probability disasters follow a two-stage process: participation (Stage 1) and spending (Stage 2).*

Although we are not aware of any direct way of proving that individuals follow such a two stage-process, this hypothesis would be supported if one could show that *participation* (Stage 1) is determined by different variables than *spending* (Stage 2).

*H2: The probability of the loss is only relevant for the spending decision.*

Hypothesis 2 is based on construal level theory. To date, construal level theory has mostly been used to understand intertemporal choice (e.g., Trope and Liberman 2003). In this context Sagristano et al. 2002 found that probabilities are very important for near-future gambles, but that they lose their importance when the temporal distance is increased. The reason is that people use higher level goals to represent distant-future than near-future activities and that lower level goals become more relevant for near-future activities (Trope and Liberman 2003). Although our research question does not involve temporal differences the findings from these studies appear relevant. As Bar-Anan et al. (2006) demonstrate, construal level theory holds for a variety of distances such as temporal distance, spatial distance and social distance. It is the

*psychological distance* that matters. We expect the *participation* decision will not be influenced by the details of the decision situation such as probabilities. However, when an individual feels that a certain risk is relevant, then he or she will want to probe into the specifics of the decision situation.

Decisions on how much to pay for protection against low-probability high-consequence events have been shown to be impacted by the precision of the information on the risk you have and the concern the hazard stimulates. Einhorn and Hogarth (1985) show that the extent to which the probabilities of losses are known to an individual makes a difference. With very low probabilities of losses, individuals are likely to overestimate the probability of the loss when they are uncertain or ambiguous with respect to its value. Construal level theory implies that the *existence* of probability ambiguity should only matter for *participation* because people will not put much effort into estimating its value when they view risk from a distance. For the spending decision individuals will attempt to estimate the likelihood of the event occurring so the effect of ambiguity will be absorbed by the estimated probability.

Caplin and Leahy (2001) suggest that a plausible anticipatory emotion with *losses* is *concern* or worry (citing MacLeod, Williams, and Bekerian 1991, p. 478) who note that “Worry is [...being] concerned with future events where there is uncertainty about the outcome, the future being thought about is a negative one, and this is accompanied by feelings of anxiety” We contend that the larger the concern, the higher should be the interest in purchasing insurance because coverage buys the individual peace of mind. We expect concern to be important for both stages of the decision. It is important for *participation* because without any impact on peace of mind we expect most people will not examine the risk in more detail. It is also important for *spending* because the maximum WTP for obtaining peace of mind is most probably dependent on the amount of concern stimulated by the potential disaster.

## C – Experimental design and sample

### Sample

Students from a major German university participated in the experiment. They were recruited via email, announcements in the main University building, and short presentations in classrooms. They were told that the experiment would take 90 minutes, that all participants would receive 10 DM for sure, and that there was a small chance (not specified in advance) that they would earn 2,000 DM at the end of the experiment.<sup>1</sup> The experiment was carried out in groups of six to ten students each of whom were situated in a separate booth. Nine subjects had to be excluded because of nonsensical responses.<sup>2</sup>

### Basic features and experimental conditions

*Objects at stake:* Participants were told that they had inherited either a painting or a sculpture and each received a small photo of the art object with an individual identification number. It was announced that only **one** painting or sculpture was an original, worth 2,000 DM; if it was a forgery then it had zero value. All participants learned that one person in the experiment would have the original art object. This individual would be determined by a random draw. This is an extreme form of the random pay mechanism suggested and investigated by Bolle (1990).

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<sup>1</sup> Given the current exchange rate between EUR and US \$ and the approximately 1 to 2 exchange of EUR against DM, this stake is worth about 1,300\$.

<sup>2</sup> These subjects were excluded from the analysis mostly because they either wanted to pay more for insurance than the value of the object to be insured or because they clearly misunderstood the experimental situation by assuming there were paying for the object rather than for an insurance policy.

*Nature of the risks, experimental conditions, and timing:* The original painting or sculpture was threatened by fire and theft. Participants were offered insurance protection against a potential loss of 2,000 DM. It was made clear that the insurer would only sell a policy to the owner of the original, and that insurance purchased by others would be hypothetical and not influence their final wealth level. In other words only the owner of the original actually would have to pay for the policy. We made it clear that it was in everyone's best interest to anticipate being the owner of the respective original when determining the maximum amount they would be willing to pay for an insurance policy. In addition to providing written instructions a flow diagram was presented to subjects describing the key variables and the decisions they had to make. All questions were answered, and the procedure was explained again whenever necessary. The extensive instructions are available from the authors upon request.

In part A of the experiment each participant inherited a painting. The original was threatened by the following ambiguous two risks: the painting was declared to be stolen if it would rain exactly 23 days in July in the respective year at the Frankfurt Airport; a fire occurs and destroys the painting if it would rain exactly 24 days in that year at the same airport.<sup>3</sup> The experiment was carried out in the spring of 1999.

We define ambiguity as a state of mind in which the decision maker is uncertain about the relevant probabilities. Whereas rain frequencies may be precisely estimated by meteorologists, they will be ambiguous for most if not all the participants in the experiment. This situation was designed to resemble a real life risk (e.g. a fire or theft in ones home) where insurers estimate annual loss probabilities across all policyholders but the individual homeowner views these risks as ambiguous.

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<sup>3</sup> Students were informed that a day is defined as a rain day by the weather station in Frankfurt if there is more than one millimeter of rain that day.

On the basis of actual Frankfurt weather data from the year 1870 to the present, we estimated the probability of each of these events occurring to be approximately 1 in 10,000.<sup>4</sup> In Group 1, respondents were informed about theft or fire threatening the original painting. They were only told that the chances of either theft or fire occurring equivalent to the above rain frequencies in July and August in Frankfurt respectively. Respondents were then asked to state their maximum WTP first for theft insurance and then for fire coverage. Group 2 differed from Group 1 in that respondents were asked to state their maximum WTP for one insurance policy covering both fire and theft damage. Risks were however still presented separately.

In part B of the experiment the participants in Groups 1 and 2 were subject to the same treatments as in Part A. The only difference was that the sculpture (instead of the painting) was threatened by theft and fire, each of which was specified as having a probability of 1 in 10,000 of occurring. To determine whether a fire had occurred two random draws with replacement were taken from a bingo cage containing 100 balls. The same procedure was followed to determine whether a theft occurred.<sup>5</sup> The experimental design is depicted in Table 1.

Note that the ambiguous probability situation is always presented first. If we had initially presented the exact probability scenario to some of the respondents, they might have anchored on this figure when estimating the likelihood of rain in Frankfurt, potentially distorting our results on ambiguity. There was no feedback at all between parts A and B of the experiment so that

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<sup>4</sup> Rain frequencies were analyzed for consistency with different distribution forms for random events, e.g. normal, binomial. Rain frequencies were consistent with a Poisson distribution (KS-test of deviation: n. s.). Rainy weather like this was fortunately never experienced in the period from 1870 to today in Frankfurt.

<sup>5</sup> A theft or fire was assumed to occur if the number 1 was pulled out twice from the bingo cage.

respondents could not learn anything from the situation presented in A when they made a decision in B.

Insert Table 1 about here
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***Eliciting WTP for insurance:*** There were no fixed selling prices for the insurance policies. Instead, we utilized a modified Becker, DeGroot and Marshak (BDM) (1964) mechanism for eliciting maximum WTP values. This modified mechanism was first introduced to laboratory research by Schade and Kunreuther (2001) and has recently been used in the marketing literature to reveal reservation prices at the point of purchase (Wang et al. 2007). In the original BDM-procedure, respondents face a random draw of selling prices for the respective object and are informed about the distribution of these prices. In theory it is incentive-compatible to state prices as being equal to reservation prices under these conditions, but there are practical problems in utilizing this method (Becker, DeGroot, and Marshak 1964). When utilizing the standard BDM procedure for eliciting reservation prices for single-stage lotteries, decision makers may already apply the reduction axiom without obeying the independence axiom, leading to distorted probability distributions (see Safra, Segal, and Spivak 1990). Pre-specified intervals of WTP in the original BDM may serve as anchors, thus biasing individuals' estimates (Bohm, Lindén, and Sonnegard 1997). Such a bias is impossible in our procedure where the actual selling prices for each of the insurance policies were inserted in sealed envelopes to be opened only after the experiment was conducted. This undisclosed price was selected before the start of the experiment on the basis of pretest results with respect to WTP, so that about one half of the respondent's bids could be expected to be higher than the pre-determined price.

The mechanism was carefully explained to the subjects so that they understood that it was designed to elicit their maximum willingness to pay. We noted that if they bid too high they may

actually pay that price should they be the owner of the original painting and they might regret having made such a high offer. If they bid too low they may not qualify for any insurance even though they would have been willing to purchase coverage at a higher price than their stated value. Respondents were then asked to write their maximum willingness to pay for the respective insurance policy on a piece of paper and place it in an envelope.

***Eliciting subjective probability estimates:*** After stating maximum buying prices for insurance, respondents were then asked to estimate the probability of each of the ambiguous risks. We distributed tables with likelihoods of a loss ranging from certainty to 1 in 10,000,000. We utilized a two-stage-approach. Respondents were first asked to mark the probability of a fire or theft causing a loss in one of 15 intervals (e.g. the chance was between 1 in 5,000 and 1 in 10,000). Respondents could also indicate that the risk was less than 1 in 10,000,000. After they checked one of the intervals, they were then asked for their best point estimate of a loss. The probability table is included in the Appendix.

***Eliciting the level of concern:*** As part of the experiment all subjects were asked the following simple question, separately for parts A and B of the experiment: “How concerned are you with respect to losing the painting (sculpture)?” Answers were provided on a 10-point rating scale with 1= *not concerned at all*, to 10= *very concerned*. Subjects knew that the actual outcome would only be determined after data were obtained from the Frankfurt airport in July and August as to how many days were classified as having precipitation.

It turned out to be quite a wet summer in the respective year, raining 13 days in July and 15 days in August. The student designated as having the original painting was not insured, was quite concerned during the rainy summer, but eventually received the 2,000 DM in cash. The other subject was insured but would not have needed insurance since the random draw from the

bingo cage – that we nevertheless carried out – did not lead to either fire or theft occurring. Hence, this student also received 2,000 DM. He paid only 7 DM for insurance.

## **D – Results and data analysis**

First, we show the descriptive results of the experiment. Then, we present the findings from a panel-econometric threshold model analyzing the covariates of the decision processes for *participation* and *spending*.

### **Descriptive results**

Table 2 compares the behavior of the 168 subjects in the experiment when the likelihood of the event was ambiguous and when the probability was precisely specified. In both cases, the expected loss of either fire or theft occurring was approximately 0.4 DM (i.e. approximately  $2/10,000 \cdot 2000 \text{ DM}$ ). 29 subjects specified  $\text{WTP}=0$  in the ambiguous case and 59 subjects had  $\text{WTP}=0$  when the probability was specified. In the condition with specified probability, there were only 10 individuals (6% of N) whose WTP was within the range of  $.5 E(\text{Loss})$  and  $5 E(\text{Loss})$  and 69 respondents (41.1% of N) were willing to pay premiums that were more than 5 times  $E(\text{Loss})$ . When the likelihood of the event was ambiguous, only 2 individuals (1.2% of N) were located in the interval between  $.5$  and  $5 E(\text{Loss})$  and 137 individuals (81.5% of N) were willing to pay more than 5 times  $E(\text{Loss})$ . The values of WTP varied between 0 DM and 1690 DM. For those who considered purchasing insurance, their mean WTP far exceeded the expected loss by a factor of 180 in the precise risk treatment (72 DM) and by a factor of 478 in the ambiguity treatment (191 DM).<sup>6</sup> These results are consistent with the low-probability insurance puzzle (Kunreuther 1978; McClelland, Schulze, and Coursey 1993). In the

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<sup>6</sup> Mean values include observations with a WTP of zero.

McClelland et al. (1993) experiment, the results exhibited the same general pattern as in our experiment but were less extreme for two reasons: multiple repetitions made the outcome of the low-probability event more predictable and the probability of a loss was higher than in our study (1%). Still, in their first study where there was a potential loss of \$4, the bid was zero in more than 25% of the cases and respondents' WTP were as high as 18 times the expected loss. In their second study (potential loss of \$40), 15% of the bids were zero and bids were as high as 35 times the expected loss.

Table 2 also shows that both the proportion of individuals who want to purchase insurance and the average WTP are significantly higher<sup>7</sup> for the cases where probabilities are ambiguous rather than known precisely. Furthermore, subjects were significantly more concerned about a potential loss in the ambiguity condition.<sup>8</sup> The mean estimate of the likelihood of experiencing a loss was 365 times the actual probability based on statistical data (7.3% instead of 0.02%). In order to neutralize outliers, we also calculated the geometric mean and the median. The geometric mean is 1.02%, the median is 2.44%. Based on the geometric mean, the mean estimate is still 50 times the actual probability. These results illustrate the immense difficulty individuals have in determining the value of protection against a highly unlikely but potentially devastating loss. They are also consistent with the Einhorn and Hogarth (1985) model since small probabilities are overestimated when they are ambiguous.

Insert Table 2 about here
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<sup>7</sup> Group means are not equal with >99.99% confidence according to a Wilcoxon test.

<sup>8</sup> Group means are not equal with >99.99% confidence according to a Wilcoxon test

### **Threshold Model with unobserved heterogeneity**

To identify the relevant covariates of the *participation* and the *spending* decisions, we estimate a panel econometric threshold model that controls for unobserved heterogeneity. Consistent with our theoretical deliberations (see Section B) individuals are assumed to utilize the following sequential decision process:

*Stage 1:* Determine whether or not to purchase insurance (*participation*).

*Stage 2:* Determine how much to pay should one decide to purchase coverage (*spending*).

Treating the decision process as a two-stage process is a generalization of the well-known Tobit model (Tobin 1956) for the analysis of corner solution outcomes, such as WTP, which have significant probability mass on a lower or upper bound of an otherwise continuous response variable. A Tobit model for analyzing WTP assumes that the decision to purchase is qualitatively identical to the decision as to how much to pay for it. Our two stage approach not only relaxes this assumption but allows the coefficients for the participation decision and the spending decision to be different.

This enables us to analyze whether the covariates driving the participation decision are the same as the covariates driving the spending decision, i.e. whether or not the two stages are qualitatively different processes as stated in H1 and the following discussion (see Section B). This approach also allows us to test H2 stating that probabilities are only relevant for the spending decision.

Two-stage approaches for the econometric analysis of corner solution outcomes have been previously suggested and applied to cross-sectional survey data (Jones 1989, Melenberg

and van Soest 1996). These studies show that numerous consumer decisions follow the above sequence when the decision on whether to purchase an item is influenced by different covariates from the ones determining how much to spend. In analyzing individuals' cigarette consumption in the UK, Jones (1989) finds that the decision to smoke is qualitatively different from the decision on how much to smoke. Individuals who believe that smoking is more harmful than drinking are less likely to start smoking; but for those who smoke, this belief does not significantly reduce average cigarette consumption. In a similar spirit, Melenberg and van Soest (1996) analyze vacation expenditures of Dutch families and find that the income elasticity is about 0.7 for the participation probability, but 1.7 for expected expenditure for families who decide to take vacation. They conclude that single equation regression models are too restrictive to reflect these qualitative differences between participation and spending.

Based on these earlier studies and taking advantage of the panel structure of our experimental data, we model the purchase of insurance as a two stage decision process in the following way:

$$(1) \quad P(a_{it} = 1 | X_{it}, c_i) = \Phi(X_{it}'\delta + c_i); \quad P(a_{it} = 0 | X_{it}, c_i) = 1 - \Phi(X_{it}'\delta + c_i) \quad t = 1, 2$$

$$(2) \quad y_{it}^* = X_{it}'\gamma + c_i + u_{it}$$

$$(3) \quad WTP_{it} = 0 \text{ if } a_{it} = 0; \quad WTP_{it} = y_{it}^* \text{ if } a_{it} = 1$$

where

$a_{it} = 1$  indicates participation and  $a_{it} = 0$  indicates no participation,

$\Phi$  is the standard normal distribution,

$c_i$  are unobserved individual specific effects related to the propensity to participate in (1) and the magnitude of WTP in (2)

$X_{it}$  is a vector of explanatory variables that includes a constant term and

$x_{1,t=1}$  = individual subjective probability judgment for the ambiguous risk

$x_{1,t=2}$  = 0.0002 for the precise risk

$x_2$  = expressed level of concern

$x_3$  = dummy variable for  $t = 1$ , the ambiguity condition

$x_4$  = dummy variable for separate policies for the two risks.

In addition, an interaction between *concern* and *ambiguity* ( $x_2 * x_3$ ) is included in the model. Based on construal theory discussed in section B, we expected ambiguity or how unpredictable the occurrence of the event is as well as the level of evoked concern to be processed as some general characteristics of the risk in Stage 1 and hence relevant for *participation*. We could not exclude the possibility of an interaction of these two qualitative variables at least for participation.<sup>9</sup>

Equation (1) is essentially a probit model that characterizes the probability that an individual wants to purchase and hence participate in insurance. Equation (2) is a linear model that estimates how much an individual is willing to pay for insurance, using observations with  $WTP_{it} > 0$  only. Equation (3) specifies that the decision to participate precedes and therefore dominates the decision on how much an individual is willing to pay. In other words, indicating

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<sup>9</sup> For reasons of consistency between the regression parts for participation and spending, the interaction was also integrated in the spending equation. We had no plausible reasons to expect further interactions.

interest in purchasing insurance is the threshold to be overcome before one decides on how much to pay for coverage.

The part of the variance in the dependent variable that is unexplained by  $X'_{it}\delta$  and  $X'_{it}\gamma$  can be decomposed into an idiosyncratic random error term that is “redrawn” for each individual in each period ( $u_{it}$ ), and unobserved individual specific effects ( $c_i$ ) that do not change over time (also known as unobserved heterogeneity). This latter term captures all individual characteristics that are unobserved in the data, but might nevertheless have a systematic impact on individual behavior. Examples of such unobserved effects are intelligence, education, prior experience and/or risk preferences. Hutchinson, Kamakura and Lynch (2000) stress the importance of unobserved heterogeneity as an alternative explanation in experimental studies. To address this potential problem our model controls and tests for unobserved heterogeneity ( $c_i$ ) explicitly. We assume that

- I. the idiosyncratic error is independently distributed with a mean of zero,  $E(u_{it} | X_{it}, c_i) = 0$
- II. the unobserved individual specific effects are independent of  $X_{it}$ ,  $E(c_i | X_{it}) = E(c_i) = 0$  and
- III. the idiosyncratic error in the spending equation is strictly exogenous and independent from the participation decision,  $E(u_{it} | X_{it}, a_{it} = 1) = 0$ .

I. and II. are the classical random effects assumptions of panel econometrics (Wooldridge 2002, ch. 10). Assumption III. allows us to estimate both equations (1) and (2) separately (Jones 1989, Melenberg and van Soest 1996).<sup>10</sup>

Table 3 reports the estimation results of the threshold model specified above. The significant  $\eta$  values show that unobserved heterogeneity is significant both for participation and for spending.<sup>11</sup>

Insert Table 3 about here
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As shown in Table 3, the participation decision and the spending decision are qualitatively different, thus lending support to H1. Consistent with our reasoning in Section B, individual concern is the only observed variable which has a strong positive influence on both the spending and the participation decision. Consistent with H2, probability judgments have a significantly positive influence on the spending decision, but their influence on the participation decision is insignificant.<sup>12</sup> As expected, ambiguity as a discrete factor increases the propensity to purchase insurance (*participate*), but its direct influence on the spending decision is insignificant.<sup>13</sup> However, it has an indirect influence in that individuals estimate the probability of a loss to be much higher when it is ambiguous rather than precise.

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<sup>10</sup> The main reason for a possible violation of this assumption in a cross-sectional setting is unobserved heterogeneity. Since our panel model is controlling for unobserved heterogeneity in both equations (1) and (2) explicitly, assumption III. is unlikely to be critical for the estimation results.

<sup>11</sup>  $\eta$  measures the share of the unexplained variance in the model that is due to unobserved individual-specific effects rather than completely random disturbances.

<sup>12</sup> In running the regressions we utilized subjective probability estimates for the ambiguous risk ( $x_{3,t=1}$ ) and  $x_{3,t=2} = 0.0002$ , i.e. the objective risk for the non-ambiguity treatment.

<sup>13</sup> The between-subjects framing condition whether individuals could purchase separate or bundled policies for the two risks does not show any significant effect in the regression. This implies that the bundling of insurance policies for the fire and theft risks does not significantly influence the probability of purchasing coverage or the magnitude of WTP.

We finally find a marginally significant negative interaction effect between concern and ambiguity in the participation equation implying that when the probability is ambiguous, the degree of concern plays a less important role than if the person is certain as to what the chances of a loss are.<sup>14</sup> We are going to address this finding in the discussion section.

In addition to the random effects threshold model in Table 3, we also estimated a variety of alternative model specifications to test the robustness of these results.<sup>15</sup> All of these specifications yield qualitatively identical coefficient signs and significance levels to the results reported above.

To illustrate the magnitude of the estimated effects of concern, ambiguity and probability perceptions, we use *descriptive data* from the sample. Consider the treatment with probabilities specified precisely. 29% of the individuals with the lowest level of concern (i.e., 1) purchase insurance. Their average WTP is 7DM. Under the same treatment, all of the individuals with the highest level of concern (10) purchase insurance, and have an average WTP of 236DM.

Ambiguity increases the percentage of those purchasing insurance from 65% to 83%, while it increases the average willingness to pay from 72DM to 191DM (Table 2). In other words, ambiguity makes individuals significantly more likely to consider the purchase of insurance. However, as indicated above, the increased willingness to pay amounts in the ambiguity treatment is due to the higher estimates of likelihood of a loss than when the probability is specified precisely (see Table 2).

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<sup>14</sup> The interaction between concern and ambiguity is positive but statistically insignificant in the spending equation.

<sup>15</sup> Alternative specifications included a fixed-effects model on WTP, ordinary probit and OLS models for t=1 and t=2 separately, and models testing for non-linear effects of concern on WTP and participation. The results are available from the authors upon request.

To illustrate the influence of higher values of perceived loss probabilities, consider the following example: For individuals with an average level of concern (3) and a subjectively perceived loss probability of less than 1%,<sup>16</sup> the average WTP under ambiguity is 54DM. An increase in the subjectively perceived loss probabilities to more than 10%<sup>17</sup> leads, *ceteris paribus*, to a substantially higher average WTP of 128DM. However, under the same circumstances, the proportion of individuals purchasing insurance increases only marginally from 90% to 100%. This is in accordance with the insignificant influence of perceived loss probabilities in the participation equation estimation (Table 3) and with H2 based on construal level theory.

## **E – Discussion**

### **Confirmation of hypotheses and theory**

Participation and spending are driven by different factors, and the types of factors that are relevant for these decisions are consistent with construal theory. This lends support to H1 and H2 and a two-stage model where individuals initially exhibit a large psychological distance with respect to the risk when making their *participation* decision (Stage 1). Only those who judge the risk as relevant for consideration based on general characteristics such as concern, look at the likelihood of the event occurring when determining their *spending* decision (Stage 2).

By explicating the processes behind participation and spending, we can provide explanations for both parts of the low probability insurance puzzle: (a) zero WTP and (b) WTP far above expected loss.

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<sup>16</sup> 25% of subjects in this treatment stated probability values of less than 1%.

<sup>17</sup> 21% of subjects in this treatment stated probability values of more than 10%.

### **Participation implies looking from a distance**

The participation decision: zero or non-zero WTP, is driven by the existence of ambiguity and the level of concern. Both factors are general characteristics of the decision situation that imply that individuals look at from a distance when deciding whether or not this risk is relevant. Probability of a loss is statistically insignificant and the positive coefficient is very small, so it effectively plays no role in the decision on whether or not to purchase insurance. There also is a significant negative interaction effect between concern and ambiguity primarily due to the relatively small percentage of individuals (17.3%) who decide not to purchase coverage when they are uncertain of the likelihood of a loss. Hence there is less room for an additional impact of concern on the participation decision relative to the precise probability treatment when more than 35 % of the subjects have WTP=0.

This decision process is consistent with what construal level theory would predict with respect to decisions and judgments made in a large psychological distance: Only higher-level goals such as “peace of mind” and general characteristics of the situation such as the *existence* of uncertainty are relevant. It is also consistent with why some individuals have a zero WTP for insurance although there is a positive probability of a loss. Probabilities do not impact on the *participation* decision, so that a zero WTP will be specified by all those individuals judging the risk as irrelevant. The inability to imagine low-probability events may play an important role, here (Newell, Mitchell, and Hayes 2008).

### **Spending is looking at the details**

Unlike the participation decision, the spending decision for individuals with WTP>0 is driven by probability of a loss and level of concern. Individuals’ decision processes for spending

involves looking at the details of the situation, the probability of a loss is now relevant. Estimating the impact of the probability of a loss when considering the purchase of insurance is demanding for low probability events, as individuals have difficulty distinguishing between likelihoods that vary by as much as 100-fold (Kunreuther, Novemsky, and Kahneman 2001). Investing time and effort only makes sense if the risk associated with a particular event is judged as relevant.

Sunstein (2003) contends that people tend to neglect probability when focusing on the badness of the outcome when they have strong emotional feelings attached to the event. We find that probabilities are indeed neglected in the decision as to whether or not an event is judged as worth considering (i.e. the participation decision). However, probabilities appear to be used in determining WTP for insurance protection after one decides to take this event seriously.

In the *spending* decision process the extremely high values of WTP suggest that those individuals who see the risk as relevant are willing to invest monetary resources into having peace of mind. This treatment is not considered in most normative models of choice and has only recently been integrated into a formal decision calculus by Caplin and Leahy (2001). It also has been explicitly incorporated into a descriptive model of choice by Krantz and Kunreuther (2007) that focuses on the importance of goals in influencing choice. Using insurance as a paradigmatic example, these authors explicitly introduce *peace of mind* as a goal that may be important to many individuals when deciding how much to pay for insurance. The other determinant of the very high WTP values of some of the individuals is the likelihood of a loss which will be overestimated if the probabilities are not specified precisely and are highly uncertain as they are for low probability events.

**The impact of “unobserved heterogeneity”**

In section D, we reported on significant values for the unobserved heterogeneity parameter for both participation and spending. Controlling for unobserved heterogeneity is important to get unbiased and efficient estimates. Hence, the results of our regressions are more reliable by including these parameters. However, what is the meaning of having significant unobserved heterogeneity with respect to our research question?

It just means that other factors besides the level of concern, the existence of ambiguity, and the estimated probabilities may explain participation and spending decisions. What would be hidden in the error term of a standard regression is now interpretable as individuals' different propensities to take a risk serious and to determine how much to spend on protection. These factors might include wealth, age, income and other socio-economic characteristics. The importance of unobserved heterogeneity in both parts of the decision can thus be interpreted as indicating the need for future research into the individual determinants of participation and spending decisions based on psychological as well as economic parameters.

## **F – Prescriptive Implications and Future Research**

Individuals have the ability to tune out of low probability hazards with potentially severe consequences. They first look at risks from a distance and decide to consider only some of them. There is a tendency to avoid investing too much time and attention into estimating probabilities for all risks so as to reduce cognitive effort. Peace of mind may also not be achieved if individuals were consciously dealing with all the risks they face in their everyday life.

Those individuals who view a specific risk as not worth considering, are not willing to pay anything for protection. Hence insurance subsidies will not convince them to purchase a

policy. It may thus be necessary to require individuals to purchase insurance as is currently the case for homeowners' coverage in the United States against losses from fire, wind damage and other low probability events where banks require this insurance as a condition for a mortgage.

There are other risks where regulatory agencies would like people not to tune them out such as health risks from smoking or dangerous activities where the government (and hence all taxpayers) bears a portion of the costs of those dangerous activities by subsidizing the health system. It is an ethical question, however, as to what risks regulatory agencies have the right to destroy peoples' peace of mind and steer up concern. Is hiking in the wilderness or just driving a car among them? Peace of mind has a monetary value to individuals' as their insurance decisions demonstrate.

Our findings also suggest that insurers can charge a premium considerably in excess of expected loss when probabilities are extremely low and still generate considerable demand for coverage. Those consumers who want insurance are the ones most concerned about a loss. This concern may be generated by past experience with an event as shown by empirical studies on purchasing flood or earthquake insurance (Kunreuther et al 1978; Palm 1993). In the case of terrorism risk a national field survey conducted in November 2001 revealed that Americans living within 100 miles of the World Trade Center felt a greater personal risk from terror than if they lived further away (Fischhoff et al 2002). This may explain the large demand for terrorism insurance coverage immediately after September 11<sup>th</sup> even at extremely high premiums (General Accounting Office 2002; Wharton Risk Center 2005).

Insurers can also take advantage of the knowledge that ambiguous probabilities lead to higher WTP than well-specified estimates of the likelihood of an event. This may be why one rarely learns from an insurer about the chances of making a claim at the time one purchases a

policy. Providing these data to consumers would enable them to determine what risks they should focus on, although as we have shown it may also lead them to ignore certain events where they can suffer severe losses.

Future research on judgment and decision making should look more carefully at different types of risks to determine which ones are single-stage decisions (as assumed in most models and studies) and which are two-stage processes. High-stakes experiments with low probability events and econometric threshold models appear to be useful tools for pursuing this line of research. Two stage processes have also been found to occur when a lottery has a risk as well as a time dimension so that the existence of a non-simultaneous evaluation of different aspects of alternatives appears in other contexts (Onculer and Onay 2008).

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Table 1: Experimental design

		<b>Within subjects treatment: ambiguity</b>	
		<b>Part A of experiment: inherited painting - ambiguity</b>	<b>Part B of experiment: inherited sculpture - known risk</b>
<b>Between subjects treatment: bundling insurance</b>	<b>Group1 (n=87): separate policies</b>	<b>Rain frequencies</b> in July and August each with probability of <b>1 in 10,000</b> ; <b>separate insurance</b> for each of the risks	Two <b>precise risks</b> each with probability of <b>1 in 10,000</b> ; <b>separate insurance policies</b> for each of the risks
	<b>Group 2 (n=81): bundled policy</b>	<b>Rain frequencies</b> in July and August each with probability of <b>1 in 10,000</b> ; <b>one insurance policy</b> for both risks	Two <b>precise risks</b> each with probability of <b>1 in 10,000</b> ; <b>one insurance policy</b> for both risks

Table 2: Descriptive results

	<b>Participation (WTP &gt; 0)*</b> <b>(Percentage of Individuals)</b>		<b>WTP for insurance**</b>		<b>Probability</b>		<b>Concern***</b>	
<b>Treatment</b>	Ambiguity	Precise Risk	Ambiguity	Precise Risk	Ambiguity	Precise	Ambiguity	Precise Risk
<b>Mean</b>	82.7%	64.9%	191 DM	72 DM	7.3%	0.02%	4.6	4.0
<b>Minimum</b>	-	-	0	0	0.00001%	0.02%	1	1
<b>Maximum</b>	-	-	1690 DM	1200 DM	83%	0.02%	10	10
<b>Std. Deviation</b>	-	-	294	162	0.12	0	2.9	2.8
<b>N</b>	168	168	168	168	160	168	168	167

\* Persons having a WTP > 0 for both theft and fire insurance or bundled insurance.  
 \*\* In group 1, WTP was elicited separately for theft and fire insurance and then added. In group 2, WTP was elicited for a bundled insurance against fire and theft in the first place. WTP among the two groups did not differ significantly (p-level (MWU): 0.11, two-sided).  
 \*\*\* Concern is significantly higher in the ambiguity treatment than when the probability is given precisely. The null hypothesis of equal medians / means can be rejected with 94.9% (Mann-Whitney U Test) / 93.4% (T test) confidence.

Table 3: Random effects threshold model estimation results

	<b>Threshold Model</b>			
	<i>a (participation)</i>		<i>y* (WTP)</i>	
	Coef. (Std. Err.)	Z	Coef. (Std. Err.)	Z
$x_1$ (prob)	4.22 (2.79)	1.51	562.23** (157.20)	3.58
$x_2$ (concern)	0.51** (0.10)	5.22	19.90** (7.91)	2.52
$x_3$ (ambiguity)	1.52** (0.49)	3.10	35.12 (53.85)	0.51
$x_4$ (separate policies)	-0.29 (0.36)	0.42	-55.01 (37.05)	-1.48
$x_2 * x_3$	-0.20* (0.12)	-1.69	9.45 (9.25)	1.02
Constant	-0.91** (0.38)	-2.41		
<b>Model diagnostics</b>				
Number of observations	327 <sup>+</sup>		327 <sup>+</sup>	
Number of individuals	168		168	
R2 (overall)	n/a		0.165	
Prob > chi2	0.00		0.00	
Log likelihood	-129		n/a	
$\square$ (unobserved heterogeneity)	0.70**		0.424**	
<p>* denotes significance at 90% confidence  ** denotes significance at 95% confidence  <sup>+</sup> The number of observations is not twice the number of individuals because there are some missing values for the level of concern and the probability estimates in part A of the experiment.</p>				

## Appendix

### A.1 Experimental Instructions (translations of parts A and B of the experiment)

#### *Group 1 (separate policies)*

##### Part A: Ambiguity

- You inherited a small painting and have received a photograph of it. The photo carries an individual identification number. You do not know if the painting is an original or a reproduction. If it is an original it is worth 2,000 DM. If it is a reproduction it is worth nothing.
- One person in the entire group of respondents participating in our experiment (about 260 to 280 people) has an original painting. All others have reproductions. Which one of the paintings is the original will be determined by a random draw symbolizing the decision of an art appraiser at the end of the entire experiment. The person who has the original painting will actually receive the value of the painting: 2,000 DM (in real bills!).
- Theft and fire threaten your painting.
- Whether or not the painting will be stolen will be determined by the weather conditions in July. If it will rain on 24 days in July (not more but also not less), a theft will occur. More precisely, the painting will be stolen if the weather station at the Frankfurt Airport will report on exactly 24 days of rain. A day is defined as a rainy day if there is at least 1 mm of rain on this day.
- The weather conditions in August determine if a fire will destroy the painting. If it will rain on 23 days in August (not more but also not less), a fire will occur. More precisely, a fire will

destroy the painting if the weather station at the Frankfurt Airport will report exactly 23 days of rain. Here again a day is defined as a rainy day if there is at least 1 mm of rain on this day.

- You can buy insurance policies against either or both of these each of the risks. If you have an insurance policy against theft or fire and the painting will be stolen or destroyed by fire, respectively, the insurance will reimburse you for the loss of 2,000 DM. If you have an insurance policy against fire and the painting will be destroyed by fire, the insurance will reimburse you for the value of 2,000 DM.
- The insurance company will sell the insurance policy and charge the money for it only in case an art appraiser, represented by the random draw of the experimenter, finds out that your painting is an original. Thus for all respondents having the reproduction the payments for the insurance policies will remain hypothetical. However, for the one having the original painting they will become true and have to be paid from his/her own money.

The selling procedure for the theft insurance policy is organized in the following way:

- Before the experiment the experimenter selected a secret selling price for the theft insurance policy. He wrote it on a piece of paper and put it into the envelope on the front desk.
- You are now required to write a buying price equal to your maximum willingness to pay for the theft insurance policy on the form in front of you and to put it in the respective envelope.
- After the experiment the experimenter will open the envelope with the selling price. If your buying price is equal to or higher than the secret selling price you will have bought a are able to buy the theft insurance policy should you be the person with the original painting.(if you are the one who has the original painting). If your buying price is lower than the secret price, you are not able to buy the theft insurance policy.

- Note, that you have no information about the selling price for the theft insurance policy. The experimenter changes this price every time.
- In this situation, the best you can do is to state your true value, your maximum willingness to pay for the theft insurance policy.
- It does not make sense to state a buying price higher than your maximum willingness to pay since you may end up paying this high price.
- It does also not make sense to state a price lower than your maximum willingness to pay. If your stated price is lower than the selling price but you, in fact, would have been willing to pay that price you may end up without the theft insurance policy even if you would have liked to buy it for that price if you are the one who has the original painting.
- If you do not want to buy the theft insurance policy please state 0 DM on the respective form.
- Please do not announce your buying price to the others and do not raise questions that allow the others to guess your buying price.
- Again, note that you only have to actually pay the price for the insurance policy if you are the one who has the original painting since the insurance company will only sell the insurance policy if the painting is verified as the original. In this case. If the person who has the original painting is able to buy insurance he or she has to pay for the coverage the insurance policies from his or her own money.
- Basically, that means that you are buying insurance for the original and that you only pay for it if you have it.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

The selling procedure for the fire insurance policy is organized the following way:

- The selling procedure of the fire insurance policy is organized in exactly the same way as the selling procedure for the theft insurance policy, i.e. there again is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

#### Part B: Risk

- You inherited a small sculpture and have received a photograph of it. The photo carries an individual identification number. You do not know if the sculpture is an original or a reproduction. If it is an original it is worth 2,000 DM. If it is a reproduction it is worth nothing.
- One person in the entire group of respondents participating in our experiment (about 260 to 280 people) has an original sculpture. All others are reproductions. Which one of the sculptures is the original will be determined by a random draw symbolizing the decision of an art appraiser at the end of the entire experiment. The person who has the original sculpture will actually receive the value of the sculpture: 2,000 DM.
- Theft and fire threaten your sculpture. Both risks have a known chance of occurrence:

Hazard	Chance of occurrence
Theft	in one of 10.000 cases
Fire	in one of 10.000 cases

- A bingo cage with 100 balls will be used to determine whether or not the sculpture will be stolen and whether or not it will be destroyed by fire.

- Whether or not the sculpture will be stolen will be determined by the following two stage procedureway: If a ball with a number between 2 and 100 is drawn no theft will have occurred. With our bingo cage with 100 balls we will continue after the first draw only If a ball with carrying the number 1 is will be drawn Otherwise nothing happened. In a second draw from the bingo cage with 100 balls will be taken. theft occurs If the ball with the number 1 is will be drawn in the second stage then a theft will occur. The chance of both these events occurring is exactly 1 in 10.000.
  - Secondly we will determine if fire occurs. We will proceed with the same two-stage procedure as used for theft.
- You can buy insurance policies against either or both of these each of the risks. If you have an insurance policy against theft or fire and the sculpture will be stolen or destroyed by fire, respectively, the insurance will reimburse you for the loss of 2,000 DM. If you have an insurance policy against fire and the fire destroys the sculpture, the insurance will reimburse you for the value of 2,000 DM.
  - The insurance company will sell the insurance policy and charge the money for it only in case an art appraiser, represented by the random draw of the experimenter, finds out that the sculpture is an original. Thus for all respondents having the reproduction the payments for the insurance policies will remain hypothetical. However, for the one having the original sculpture they will become true and have to be paid from his/her own money.

The selling procedure for the theft insurance policy is organized the following way:

- The selling procedure of the theft insurance policy is organized in exactly the same way as the selling procedure for the theft and fire insurance policies in the first part of the experiment, i.e. there again is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

The selling procedure for the fire insurance policy is organized the following way:

- The selling procedure of the fire insurance policy is organized in exactly the same way as the selling procedure for the theft and fire insurance policy in the first and the theft insurance policy in the second part of the experiment, i.e. there again is a secret selling price in an envelope, and you again are supposed to state your maximum buying price.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

*Group 2 (one policy)*

The only differences between groups 1 and 2 were, that in group 2 we sold bundled rather than separate insurance in both parts A and B. Therefore the part of the instructions dealing with insurance was written up as follows in part A (B) of the experiment:

- You can buy an insurance policy against these two each of the risks. If you have an insurance policy or fire and the painting (sculpture) will be stolen or destroyed by fire, or destroyed by fire, respectively, the insurance will reimburse you for the loss of 2,000 DM.

And the selling procedure was described in the following way in part A (B) of the experiment:

- Before the experiment the experimenter selected a secret selling price for the insurance policy. He wrote it on a piece of paper and put it into the envelope on the front desk.
- In the following you are now required to write a buying price equaling your maximum willingness to pay for the insurance policy on the form in front of you and to put it in the respective envelope.
- After the experiment the experimenter will open the envelope with the selling price. If your buying price is equal to or higher than the secret selling price you are able to buy the insurance policy (if you are the one who has the original painting (sculpture)). If your buying price is lower than the secret price, you are not able to buy the insurance policy.
- Note, that you have no information about the selling price for the insurance policy. The experimenter changes this price every time.
- In this situation, the best you can do is to state your true value, your maximum willingness to pay for the insurance policy.
- It does not make sense to state a buying price being higher than your maximum willingness to pay since you may end up paying this high price.

- It does also not make sense to state a price being lower than your maximum willingness to pay. If your stated price is lower than the selling price but you in fact would have been willing to pay that price you may end up without the insurance policy even if you would have liked to buy it for that price if you are the one who has the original painting (sculpture).
- If you do not want to buy the insurance policy please state 0 DM on the respective form.
- Please do not announce your buying price to the others and do not raise questions which allow the others to guess your buying price.
- Again, note that you only have to actually pay the price for the insurance policy if you are the one who has the original since the insurance company will only sell the insurance policy if the painting (sculpture) is verified as the original. In this case. If the person who has the original painting is able to buy insurance he or she has to pay for the coverage the insurance policies from his or her own money.
- Basically, that means that you are buying insurance for the original and that you only pay for it if you have it.
- Now, please put the form with your maximum buying price in the appropriate envelope and hand it over to the experimenter.

## A.2 Probability table

Please report how probable you have judged „exactly 24 rain days in July“ occurring. Please check an interval that covers the probability you are judging to be correct first. Afterwards please report the exact probability in the right column.

Explanation: A chance of 1 in 1.000.000 implies that a July with exactly 24 rain days occurs – on average – every 1.000.000 years.

Chance: 1 in	Please check:	Exactly:
1 to 5		1 in _____
5 to 10		1 in _____
10 to 50		1 in _____
50 to 100		1 in _____
100 to 500		1 in _____
500 to 1.000		1 in _____
1.000 to 5.000		1 in _____
5.000 to 10.000		1 in _____
10.000 to 50.000		1 in _____
50.000 to 100.000		1 in _____
100.000 to 500.000		1 in _____
500.000 to 1.000.000		1 in _____
1.000.000 to 5.000.000		1 in _____
5.000.000 to 10.000.000		1 in _____
Less probable		Exactly 1 in _____