Global Risk, Investment, and Emotions*

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Abstract

We investigate a novel dynamic choice problem in an experiment where emotions are measured through self-reports. The choice problem concerns the investment of an amount of money in a safe option and a risky option when there is a 'global risk' of losing all earnings, from both options, including any return from the risky option. Our key finding is that global risk can *reduce* the amount invested in the risky option. This result cannot be explained by Expected Utility or by its main contenders Rank-Dependent Utility and Cumulative Prospect Theory. An explanation is offered by taking account of emotions, using the emotion data from the experiment and recent psychological findings.

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1 Introduction

This study focuses on the behavioral effects of 'global risk' in an investment experiment. A key feature of global risk is that it is difficult or even impossible to avoid. Important examples include global terrorism and political risk. In the wake of September 11, 2001, the specter of global terrorism has fostered feelings of insecurity, that anything can happen at any time, which cannot be escaped. This insecurity has nourished cautiousness and aversion to risky investment, at least in the short run (OECD, 2002; Samuelson, 2004). Political risk in developing and transition economies is another case in point. Empirical evidence suggests that political instability due to social unrest and ownership risk related to a country's stability have a negative effect on private investment (Alesina & Perotti, 1996; Bohn & Deacon, 2000). In general, of course, such risks may lead to the flight of capital to safer havens. However, foreign investment may not be a feasible option for many an investor in a developing or transition economy, because of high transaction costs or lack of access to foreign markets.[1] Finally, global risk could also be seen as the threat of a financial crisis. In that case both safe and risky investments could be at risk, for example due to severe financial market stress or a default of a major financial institution. Financial globalization, increased cross-border banking, and the fact that financial institutions depend ever more on global financial markets seem to make this type of global risk more prominent nowadays.

A problem with field empirical studies is that global risk is hard to isolate. Moreover, the available studies typically rely on cross-sectional data of countries that differ in many important ways (e.g., their political system, tax regime, or access to world markets). In a laboratory experiment the degree of global risk can be carefully manipulated while keeping everything else constant, which offers the opportunity of control and replication. In this paper, we study the behavioral effects of global risk by using a novel dynamic choice problem in an investment experiment. More specifically, we have subjects in the experiment distribute an amount of money over a safe option and a risky option, instead of confronting them with a binary choice as is common in experiments on decision making under risk.[2] Furthermore, we study the impact of a global risk by introducing a chance that all earnings will be lost, from both options, including any return from the risky option. In our analysis of the results we take

[1] Immediate consumption will often not be a realistic alternative either, and may even be negatively affected in case of a simultaneous loss in consumer confidence.
[2] An exception is Loomes (1991).

account of emotions, using self-reported emotion data of the experiment and recent (neuro) psychological findings.

The organization of the paper is as follows. Section 2 presents the experimental design, the theoretical predictions, and the experimental procedures. Results are given in section 3. Section 4 considers the relevance of emotions for explaining our results and offers some additional data. Section 5 concludes with a discussion.

2 Theory and experiment

2.1 Decision problem and economic theory

Baseline versus Global Risk

The decision problem we will investigate is as follows. People have an amount of money z at their disposal that they have to distribute over two options: they can invest an amount x ($0 \leq x \leq z$) in a risky option while leaving the remainder ($z - x$) for a safe option. For convenience, we will speak of investment only if the money is allocated to the risky option. The safe option yields neither a gain nor a loss, whereas the risky option gives a return of either 2.5x or 0, both with probability ½. We will compare this Baseline problem with the case where subjects know that after this game there will be a lottery determining with probability p that they can keep their earnings from the game while with probability 1–p everything will be lost. The latter case will be called Global Risk, because the probability 1–p applies equally to the earnings of both projects. The two cases are illustrated by the decision trees in figs. 1 and 2.

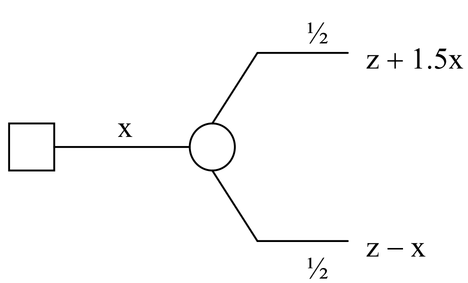

Fig. 1. Decision tree for Baseline

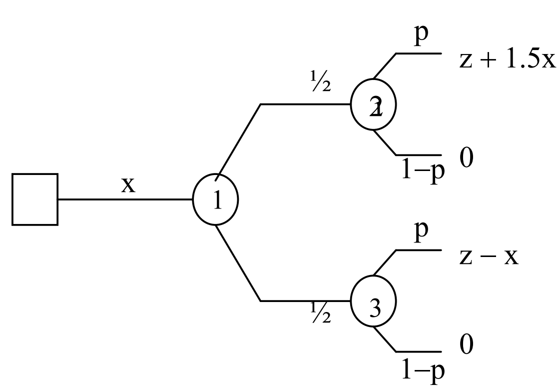

Fig. 2. Decision tree for Global Risk

Our theoretical analysis of these cases focuses on Expected Utility (EU), Rank-Dependent Utility (RDU), and Cumulative Prospect Theory (CPT).[3] The following predictions are obtained (see Appendix A, for a more formal analysis)[4].

MAIN PREDICTION: *EU predicts that investment will not be affected by global risk. In contrast, empirical applications of RDU and CPT predict that, if anything, increasing global risk will enhance risk seeking and, thus, lead to more investment (irrespective of whether 0 or z is taken as reference point in applying CPT).*

Furthermore, EU with wealth as argument in the utility function predicts that investment will concentrate at $x = z$, while EU with income (earnings) as an argument and empirical applications of RDU and CPT allow for non-extreme investment.

2.2 Experimental procedures

The experiment was run at the CREED-laboratory of the University of Amsterdam. In total 139 subjects participated in the experiments. About 64% of the subjects were students of economics or econometrics. The other 36% were students from various fields such as chemistry, psychology, mathematics, and law. Subjects were randomly assigned to an experimental condition. The investment game was framed in a neutral way, avoiding potentially suggestive terms like investment or global risk. Subjects received a show-up fee of 5 Dutch guilders (about 2.5 euros), independently of their earnings in the experiment. On average, subjects earned 32.9 guilders in Baseline (BL) and 29.0 in Global Risk (GR). The whole experiment took about 45 minutes.

We will first briefly discuss the procedures of Baseline. Before subjects play the investment game in BL and receive instructions, they get an envelope containing 30 Dutch guilders in cash. Subjects are told that this is their working money with which they may earn more money. However, it is added that they may also lose (some of) this money. If their

[3] Some other theoretical predictions will be discussed in the results section. Regret theory (Loomes & Sugden, 1982) cannot be applied because it is restricted to binary choice situations. For binary choice problems this theory predicts no effect of global risk (due to the 'separability principle'). By adopting the assumption of dynamic consistency, also Loomes & Sugden's (1982) disappointment model would predict no effect.

[4] Our analysis is based on calculations made by Peter Wakker. We are very grateful to Peter for making his analysis available to us. Of course, any error is solely our responsibility.

earnings turn out to be larger than 30 guilders, they get the difference paid out in private at the end of the experiment, on top of the 30 guilders they already received. If they make losses, they must pay these back to the experimenter – out of the 30 guilders they received – again in private and at the end of the experiment. After subjects have checked the content of the envelope they receive the written instructions of the investment game (an English translation is provided in Appendix B). Furthermore, they receive two cups (one for the safe option, denoted project A, and one for the risky option, denoted project B), a white die, and a decision form. After the instructions are read aloud and three examples are given to illustrate the game, subjects have to allocate their money to the two projects (cups). In addition, they have to write down their investment decision on a form. Immediately afterwards, subjects are asked to fill out a questionnaire with questions concerning the emotions they experienced, their motivations, and background. After filling out the questionnaire, each subject has to throw the white die (not being observed by others except for the experimenter) in order to determine the outcome of the risky project. Finally, payment takes place in private.

Table 1. Sequence of events in the different treatments of the experiment

Base Line	**Global Risk**
(1) 30 guilders in cash	(1) 30 guilders in cash
(2) instructions	(2) *announcement global risk*
(3) allocation decision	(3) instructions
A: sure return	(4) allocation decision
B: risky return	A: sure return
(4) emotion measurement	B: risky return
(5) outcome risk B	(5) emotion measurement
(6) payment	(6) outcome risk B
	(7) *outcome global risk*
	(8) payment

Global Risk is set up in exactly the same way as BL except that now a global risk is introduced. All subjects receive a written announcement and a red die immediately after the handing over of the envelope with the money (but before they receive the instructions of the investment game). The announcement – which is also read aloud – states that with probability 1/3 the subject will lose all the earnings out of the experiment. It further states that this risk will be resolved by having the subject throw the red die at the end of the experiment (after having learned the outcome of the risky project but before payment; see Appendix B). A summary of the sequence of events in the two treatments is given in table 1.

Emotions are measured through self-reports. According to Robinson & Clore (2002), self-reports are the most common and potentially the best way to measure a person's emotional experience. As Bosman & van Winden (2002), we use a list of emotion names and ask subjects to report the experienced intensity of each emotion on a 7-point scale, ranging from "no emotion at all" to "high intensity of the emotion". Subjects are asked to report their experienced emotions immediately after they have made their investment decision.[5] The list includes the following emotions: irritation, anger, anxiety, contempt, envy, hope, sadness, joy, happiness, shame, fear, and surprise. Note that not only the (negative) emotions are included that we expect to be particularly relevant in our setting (like anxiety or hope). When applying this technique, filler items are commonly used by psychologists to avoid that respondents are driven in a particular direction.

3 Behavioral results

Fig. 3 shows the distribution of investment in the risky project in Baseline. Notice that each subject invests a positive amount in the risky project; no one chooses an investment level equal to zero. More specifically, investment ranges from 7 to 30 guilders, with large spikes at 20 (the mode and median) and 30 guilders. Moreover, there are several smaller peaks at 10, 15, and 25 guilders. Thus, we do not observe the extreme investment predicted by EU with wealth as argument. In light of this prediction, the majority of subjects (75%) appears to be risk averse since they invest only part of their money in the risky project.

[5] The reason why we did not measure emotions before the decision is that we wanted to avoid any effect on the subsequent choice. One could also measure the emotion before and after the decision. A drawback of this procedure is that subjects may wish to give consistent answers. Also, people might find it odd to respond to the same questions more often in a short period of time.

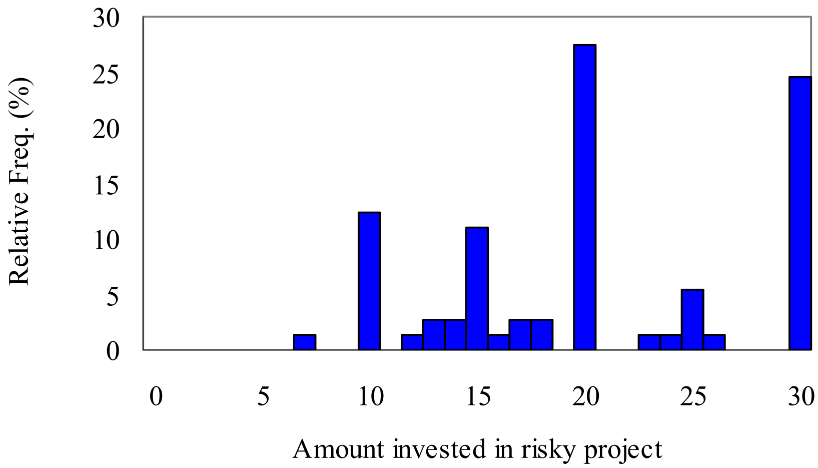

Fig. 3. Investment in Baseline (n = 73)

The other 25% of the subjects can be seen as at most mildly risk averse and may be risk neutral or risk seeking. The average investment level in BL equals 20.3 guilders (st. dev.: 6.97). Furthermore, it turns out that investment is neither influenced by gender nor by educational background (economics or not) or experience with economic experiments. The fact that gender does not have an effect is a bit surprising in light of the psychological evidence that, in general, males tend to be less risk-averse than females (Byrnes et al., 1999).[6]

[6] Holt & Laury (2002) find that the gender effect disappears in their high-payoff treatments of their decision making under risk experiment, concerning choices between lotteries.

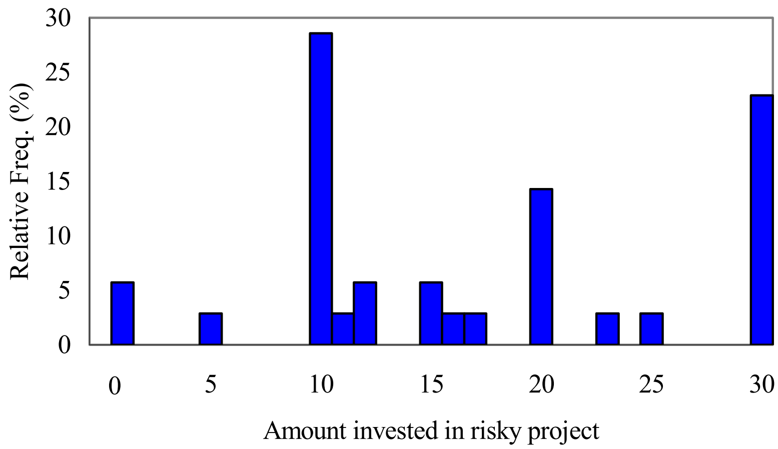

Fig. 4. Investment in Global Risk (n = 35)

We next compare Baseline with Global Risk where subjects were confronted with a probability of 1/3 to lose all their earnings whatever investment decision they would make. Fig. 4 shows the distribution of investment in GR. Clearly, a very different distribution shows up. First, instead of an inverted-U shape, a more U-shaped distribution is now observed, plus a small tail to the left (Kolmogorov-Smirnov test, $p = 0.02$).[7] Second, although there are again two larger spikes, in this case, besides the one at 30, there is another one at 10 (instead of 20), which is now also the mode. Third, investment in GR is significantly lower than in BL (Mann-Whitney test, $p = 0.04$; t test, $p = 0.03$). Average investment in GR is 16.9 (st. dev.: 9.1), which is about 15% lower in comparison with BL. The median has decreased to 15, a decline of 25%. Fourth, it turns out that, in case of GR, not only the range of investment is larger, with some subjects now investing nothing, but also the variance of investment (48.6 in BL against 82.4 in GR). The next result presents our main finding.

RESULT 1 (MAIN FINDING): *Compared to Baseline, investment decreases under Global Risk, while the distribution of investment changes from an inverted-U shape into a U-shaped distribution.*

Surprisingly, *none* of the economic theories discussed in the previous section can explain this result. Incidentally, this result also goes in the opposite direction of the common-ratio effect

[7] Unless otherwise noted, all tests in this paper are two-sided.

(an effect that can be explained by RDU and CPT).[8,9] Furthermore, it is at odds with the isolation effect discussed by Kahneman & Tversky (1979), which would predict no effect of global risk in our case. In their prospect theory, choice is modeled as a two-stage process. At the first stage prospects are 'edited' using a variety of decision heuristics[10]; at the second stage choices among edited prospects are determined by a preference function, whereby outcomes are interpreted as gains and losses relative to a reference point. The underlying idea of the isolation effect is that, as a decision heuristic, at the first (editing) stage individuals may disregard components that are shared by alternative options and focus instead on the components that distinguish them. Since in our experiment global risk can be seen as a component that is shared between the safe and the risky option, it may therefore be neglected. Although global risk is introduced in the experiment in a way that would seem to facilitate isolation, our findings suggest that this cognitive operation, if present at all, was not sufficiently strong. Hence, the question arises: what can explain our puzzling findings? In the next section we will argue that taking account of the affective side of decision-making may provide a solution.

4 Can emotions explain investment behavior under global risk?

There is a growing interest among economists in studying the role of emotions in economic decision making (e.g., Pope, 1995; Loewenstein, 1996; Bosman & van Winden, 2002; Hopfensitz & Reuben, 2007; for general discussions, see: Elster, 1998; Loewenstein, 2000, 2001). Regarding decision making under risk or uncertainty, there have been several theoretical attempts to incorporate emotions in economic models. For example, in the 1980s Loomes & Sugden (1982, 1986) and Bell (1982, 1985) formally analyzed regret and disappointment aversion. More recently, Wu (1999) and Caplin & Leahy (2001) have developed a formalization of anxiety, while Loewenstein et al. (2001) have argued in favor of a risk-as-feeling hypothesis with greater explanatory power than current cognitive-

[8] This effect refers to the experimental finding that people typically become more risk seeking when confronted with a reduced compound lottery (where all probabilities are multiplied by a common factor). Apparently, subjects in our experiment did not reduce the investment problem and global risk in this way.

[9] The result also goes in the opposite direction of the effect predicted by the 'priority heuristic' of Brandstätter et al. (2006), a simple lexicographic heuristic for choosing between two gambles that involve non-negative payoffs. This heuristic predicts that $x = 0$ (no investment) in Baseline, and that $x = 29$ in Global Risk (for any $0 < p < 1$).

[10] The function of the editing phase is to organize and reformulate the options such that it simplifies subsequent evaluation and choice.

consequentialist approaches. So far, however, economists have neglected to study experimentally the role of affect in decision-making under risk or uncertainty using explicit measures of emotions.[11] The goal of this section is to explore whether existing (neuro) psychological evidence, together with some data collected by ourselves, can help explain our experimental findings. We emphasize the exploratory nature of this section. Our ambition here is not to provide a thorough explanation where existing models apparently fail. One simple reason is that, in this first approach, we measured emotions only after the investment decision, as motivated in subsection 2.2.

Before we continue, we first provide some information regarding the nature of emotions. Emotions occur if a stimulus is deemed to be relevant for one's interests or concerns (Frijda, 1986). This occurrence is unbidden, that is, one cannot simply choose an emotion. If the appraisal is that an interest is furthered, a positive emotion, like joy or gratitude, is triggered. A negative emotion, like fear or sadness, shows up if an interest is appraised to be thwarted. Emotions imply an action tendency (urge) to approach or avoid ('fight or flight'). Brain scientists have found that different neural networks in the limbic system (the feeling part of the brain) are involved, which interact with neural systems in the cortex (the thinking part of the brain) (see, e.g., LeDoux, 1996). For example, with respect to decision making under uncertainty neuroscientific evidence exist implicating the amygdala, a small region in the limbic system with strong connectivity to the cortex (Bechara & Damasio, 2005; Kenning et al., 2006). Emotional responses to external stimuli appear to be faster than cortical responses (LeDoux, 1996). If the emotional intensity is sufficiently high, we just act without thinking. Emotions can be measured in various ways. Mostly used are self-reports of emotional intensity, like in our experimental design (Robinson & Clore, 2002). Compared to physiological measures of arousal (like heart rate), an advantage of self-reports is that one can get information about specific negative or positive emotions. Evidence shows that this is important because emotions entail different action tendencies (Zeelenberg et al., 2008). In the context of uncertainty, a case in point concerns the emotions of fear and anger involved in the 'flight or fight' response. Finally, it is noticed that different emotions can occur simultaneously and that their relative weight changes over time (e.g., depending on coping potential). In case of a threat, both fear and anger can be triggered, and fear may turn into

[11] An exception would seem to be Chew & Ho's (1994) empirical study of 'hope'. However, they simply assume that more risk seeking in case of a small probability of a future gain reflects hope. Moreover, they use hypothetical decision problems.

anger (as with the 'cornered rat'). In both events the amygdala appears to be implicated (Rubin, 1986; LeDoux, 1996; Adolphs. 2003).

4.1 Anxiety

The theoretical models of Wu (1999) and Caplin & Leahy (2001) present a formalization of anxiety due to uncertainty (risk) concerning the future outcomes of lotteries. In these models investment is assumed to trigger anxiety before the investment (decision) risk is resolved. According to Caplin & Leahy (*op. cit.*, p. 56): "the incorporation of anxiety into asset pricing models may help explain both the equity premium puzzle and the risk-free rate puzzle." The intuition is that owning stocks involves an extra psychic cost, due to experienced anxiety, which increases the required return. By ignoring anxiety, conventional measures of risk aversion would underestimate the effect of uncertainty on asset prices. In a similar vein, one might expect that the more participants in the experiment invest in the risky project, and thus the more is at stake, the more they will worry before the resolution of the risk. Our emotion measures, taken immediately after the investment decision, enable us to investigate more directly the emotions subjects experienced, including the hypothesized relationship between investment and the anticipatory emotion anxiety. We will focus first on the treatment BL.

The intensity scores of the emotions experienced in BL are reported in table 2, where the reader should neglect the second and the third column for the moment.[12] Among the negative emotions anxiety appears to be the most prominent one, followed by fear.[13] However, some positive emotions (in particular, hope) actually obtain even higher scores. To check whether indeed anxiety after the investment decision is related to investment, we have estimated an ordered-logit model with as dependent variable the anxiety score and as

[12] The number of observations regarding emotions in BL is smaller than the number of observations concerning investment because about half of the subjects in BL reported their emotions at the very beginning of the experiment, before the instructions were given. We have pooled these two groups of subjects in the investment analysis because no significant differences in investment behavior were found (Mann-Whitney test, $p = 0.28$; Kolmogorov-Smirnov test, $p = 0.43$). These emotions are not further considered here because none of them appeared to be correlated with investment behavior (Spearman rank-order coefficient, $p > 0.10$). This may be due to the fact that these subjects had not yet received any instructions about the experiment (the investment task).

[13] According to Ortony et al. (1988) anxiety is a fear-like emotion (like worry, apprehension, nervousness) that arises when the individual is displeased about the prospect of an undesirable event. The intensity depends on the degree to which the event is undesirable and the likelihood of the event. Unpleasantness, uncertainty, and situational (instead of individual) control are seen as central appraisal dimensions (Smith & Ellsworth, 1985).

explanatory variable the investment level in BL. We find a clear positive relationship between the two variables (coefficient of investment: 0.108, p = 0.03).[14]

RESULT 2. *In Baseline, anxiety experienced after the investment decision but before the resolution of the investment risk is positively related to the amount invested.*

This result provides experimental support for an important part of the anxiety models of Wu (1999) and Caplin & Leahy (2001). Not covered by our measures is whether subjects anticipated prospect based emotions such as anxiety (in this context, see Loewenstein & Schkade, 1999). The next subsection investigates the role of affect under global risk.

4.2 Affect and global risk

An important feature of global risk is the threat of losing one's resources. This threat may be important when making an investment decision because it can trigger by itself acutely experienced emotions like anxiety or fear, which may interfere with other motivational factors. Note that this experienced anxiety differs from the anticipatory emotion anxiety discussed in the previous subsection. As both are experienced (anticipatory), for later reference, we will call this type *situation anxiety*, because it is generated by the (uncontrolled) situation an individual is in, and the type discussed before *decision anxiety*, since it is related to the subject's decision.[15] In contrast with decision anxiety, the role of situation anxiety in decision making has been studied extensively in the psychological literature. Existing evidence shows that it affects behavior and thoughts in systematic ways. For example, Raghunathan & Pham (1999) find that anxious individuals are biased towards low-risk / low-reward options. Anxiety, they argue, primes an implicit goal of uncertainty reduction. Eisenberg et al. (1996) and Lerner & Keltner (2001) also find that anxiety and fear are correlated with risk-averse behavior. In their survey, Loewenstein et al. (2001) state: "many studies have found effects of fear and anxiety on various types of judgement that tend to favor cautious, risk averse, decision making" (p.271). Thus, the available psychological literature

[14] The Spearman rank-order coefficient of correlation between anxiety and investment is 0.31 (p = 0.07). Furthermore, we find that anxiety is positively correlated to fear (Spearman rank-order coefficient: 0.68, p = 0.00), which shows that anxiety is a fear-like emotion. Besides anxiety, contempt and hope are also positively related to the amount invested (ordered-logit model; p = 0.04 and p = 0.07, respectively).
[15] Situation anxiety does not play a role in the models of Wu (1999) and Caplin & Leahy (2001).

strongly suggests that situation anxiety motivates individuals to take less risk. Although these studies typically rely on hypothetical outcomes (or deception) and induced emotions (not generated by the decision task itself), applied to our global risk experiment, they correctly predict and provide an explanation for our main finding that subjects invest less in the risky project.

Also in this case (treatment GR), we can check with our emotion measures the intensity with which different emotions were experienced after the investment decision and whether anxiety is related to the investment level. The second column of table 2 presents the emotional intensity scores for GR. Again, anxiety comes out as the most prominently experienced negative emotion (now followed by irritation), while the same positive emotions show up as being important.

Table 2. Intensity scores of experienced emotions

Emotion	Baseline (n=35) mean (st.dev.)[a]	Global Risk (n=35) mean (st.dev.)[a]	Global Risk High (n=31) mean (st.dev.)[a]
Sadness	1.80 (1.16)	2.00 (1.21)	2.58 (1.82)
Happiness	3.66 (1.47)	3.69 (1.59)	2.94 (1.55)
Shame	1.37 (1.06)	1.66 (1.35)	1.32 (1.14)
Fear	2.71 (1.84)	2.51 (1.72)	2.45 (1.55)
Envy	1.57 (1.04)	1.74 (1.15)	2.26 (1.98)
Hope	5.46 (1.17)	5.23 (1.54)	4.87 (1.59)
Anger	1.26 (0.51)	1.83 (1.52)	3.00 (2.11)[I,II]
Anxiety	3.26 (1.84)	3.31 (1.76)	3.10 (2.01)
Joy	3.54 (1.38)	3.51 (1.52)	3.00 (1.61)
Irritation	1.94 (1.39)	2.77 (1.85)[I]	3.26 (2.07)[I]
Contempt	1.89 (1.69)	1.71 (1.23)	2.10 (1.74)
Surprise	2.74 (2.09)	2.46 (1.79)	3.65 (1.85)[I,II]

[a] Scores range from 1 (no emotion) to 7 (high intensity);
[I] significant difference (5%-level) between Baseline and Global Risk (High);
[II] significant difference (5%-level) between Global Risk and Global Risk High.

Comparing the scores for BL and GR, we find no significant differences, except that irritation is higher in GR (Mann-Whitney test, $p = 0.04$). At first sight, this may be surprising because one might have expected to see more anxiety in case of GR, given the role imputed to this type of emotion above. However, a closer investigation suggests that this comparison is misleading. Firstly, it is noticed that there is a positive correlation between irritation and anxiety in GR (Spearman rank-order coefficient: 0.54, $p = 0.00$), whereas there is no such correlation at all in BL ($p = 0.94$). We will return to this below. Secondly, and more importantly, given the substantially lower investment level in GR the similar scores in fact imply that anxiety per unit of investment has increased in GR. Using the above mentioned psychological evidence regarding the negative impact of situation anxiety on investment and our own finding concerning a positive relation between investment and decision anxiety, a two-way relationship between investment and anxiety presents itself. While GR induces situation anxiety, the latter's negative effect on investment in turn induces less decision anxiety. As a consequence, the level of anxiety measured after the investment decision, which is made up by both types of anxiety, may stay more or less constant. For the same reason one should expect a less positive relationship between investment and our anxiety measure in GR. For, subjects who experience greater situation anxiety (as a personality trait) are likely to invest less which would diminish their decision anxiety, so that on balance the two types of anxiety may lead to a similar anxiety score as for subjects experiencing less situation anxiety. In fact, using again an ordered-logit model, we find no relationship at all between investment and the anxiety scores in GR.[16]

RESULT 3. *Anxiety, measured after the investment decision but before the resolution of the investment risk, is not related to the amount invested in Global Risk. A tentative explanation is offered by distinguishing two ingredients in the anxiety measured in case of Global Risk:* situation anxiety *(not controlled by the subject) and* decision anxiety.*(induced by the investment decision of the subject).*

The action tendency related to situation anxiety – induced by the global risk – is to avoid risk. Why then do we observe the U-shape distribution of investment in GR, with some people indeed choosing lower levels of investment compared to BL, but others going to the extreme of full investment? A clue is provided by the higher level of irritation observed in GR, reflecting the link between uncertainty and the emotions of anxiety (fear) and anger referred to in the introduction of this section (see also Moyer, 1976; MacLeod & Byrne, 1996). Irritation is an emotion related to anger that has been found to be conducive to risk seeking (Leith & Baumeister, 1996; Lerner & Keltner, 2001). While fearful individuals show pessimistic risk perceptions and choices, angry individuals demonstrate relatively optimistic risk estimates and choices (Lerner & Keltner, 2001; Lerner et al., 2003). Thus, it seems that two simultaneous action tendencies are at work in GR, which differentiates this case from Baseline: more risk-aversion induced by situation anxiety and more risk seeking induced by

[16] A similar result is obtained for the other emotions that were measured.

irritation. Moreover, the observed correlation between anxiety and irritation shows that these conflicting action tendencies occur at the individual level.[17] If the strongest action tendency dominates the investment decision, the outcome is expected to be more extreme. This explains the U-shaped distribution in GR. To shed more light on this issue, we have run an extra experimental treatment with a substantially larger global risk, which we discuss next.

4.3 Increasing the global risk

We will now investigate what happens if the global risk is increased from 1/3 to 2/3 (that is, 1-p = 2/3 in fig. 2). We will call this case Global Risk High (GRH). Theoretically, this increase in the global risk should have no effect on our theoretical predictions in a directional sense (see section 2.1). Thus, if any behavioral effect at all, compared to Baseline, more risk seeking should be expected. Qualitatively, this is due to the fact that small probabilities of gaining something induce risk seeking in RDU and CPT. Fig. 5 shows the distribution of investment in GRH. The distribution appears to be different from both Baseline and Global Risk. In line with GR, we observe again a U-shaped distribution with one mode at 10 and another at the extreme level of 30. However, the latter is now the larger one, and overall there seems to be a shift towards more risk seeking. Average investment (18.4; st. dev.: 9.2; median is 18) is still smaller than investment in Baseline, but investment is now not significantly lower (Mann-Whitney test, $p = 0.29$; t test, $p = 0.24$). It would be misleading, however, to conclude that the behavioral outcomes are similar to BL. First of all, the investment level in GRH is not significantly different from that in GR (Mann-Whitney test, $p = 0.51$; t test, $p = 0.52$). Furthermore, the shape of the distribution of investment looks more similar to the one in GR (Kolmogorov-Smirnov, $p = 0.99$). Finally, the range of investment is larger (showing low values) and the variance is higher (48.6 in BL against 84.2 in GRH), again similar to what we observe in GR.

[17] Neural circuits involved in fear appear to be highly interconnected with (especially) circuits involved in anger (contributing to the balance between fight and flight reactions); see Panksepp (1998). In this context, it seems interesting that the number of significant pair-wise correlations between emotions is substantially higher in GR than in Baseline (41 versus 13 significant correlations, $p < 0.05$).

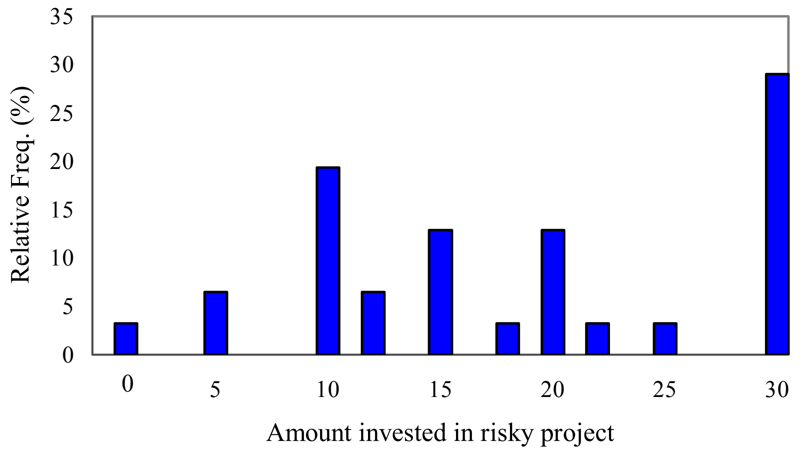

Fig. 5. Investment in Global Risk High (n = 31)

RESULT 4. *Increasing the global risk from 1/3 to 2/3 induces an (insignificant) increase in risk seeking, which leads to an average investment level that is still lower than in Baseline but no longer significantly so, It does not affect the shape of the distribution of investment as found for Global Risk, in a qualitative sense.*

To see whether our affect analysis in the previous subsection can offer an explanation for this finding, we consider the intensity scores for emotions experienced in GRH, presented in the third column of table 2. A rough comparison with BL and GR reveals that subjects were more surprised, less happy, and less hopeful. Among the negative emotions, it is no longer anxiety but irritation that gets the highest score. Next in rank is anxiety, but this emotion is now closely followed by anger. Whereas, compared to BL, statistically only irritation is stronger in GR, now in addition more anger (and surprise) is observed.[18] These results point at higher emotional arousal in case of GRH. Again, no difference in experienced anxiety is found.[19] Comparing GRH with GR, it turns out that subjects in GRH experienced more anger and surprise (Mann-Whitney tests, $p = 0.00$ and $p = 0.01$, respectively). Finally, as in GR, no correlation is found between the amount invested and the anxiety experienced after the investment decision.

[18] Anger and irritation show a correlation coefficient of 0.82 (Spearman rank-order coefficient, $p = 0.00$).
[19] Interestingly, anxiety is highly correlated with both anger and irritation (Spearman rank-order coefficients: anger: 0.90, $p = 0.00$; irritation: 0.78, $p = 0.00$)

RESULT 5. *In terms of emotions, the main differences between Global Risk and Global Risk High are that more anger and surprise are experienced in the latter.*

Since anger is conducive to risk taking, Result 5 can explain why we observe a shift (albeit an insignificant one) towards more investment in GRH, compared to investment in GR. An important element distinguishing anger from fear in what psychologists call the 'appraissal process' is certainty (next to individual control) (Smith & Ellsworth, 1985). The observed importance of anger in GRH, where the global risk is much higher and subjects may perceive the event of losing their earnings as more or less certain, is consistent with this view. This is further supported by a factor analysis.[20] In all treatments one or two factors account for more than 50% of the variance. Regarding the emotions represented by these factors we will restrict attention (mainly) to factor loadings of 0.8 or more. In the BL treatment, there are two equally important factors: a positive emotions factor, with joy and happiness as components, and a negative emotions factor, with fear as component (anxiety has a loading of 0.73). In GR, the most important factor − already explaining 49% of the variance − represents the negative emotions of irritation and anger, while a second factor comprises joy and happiness (a third and almost equally important factor contains fear and anxiety with loadings above 0.6). In GRH, the dominant factor − explaining 54% of the variance − comprises anxiety, irritation, and anger (in the next factor only sadness and envy attain loadings higher than 0.6). Thus, going from BL to GRH, we see also here that fear vanishes in importance while irritation and anger become more important.

5 Discussion

Main finding and explanation. The experimental results reported in this paper present a puzzle to expected utility as well as non-expected utility models. None of these models correctly predicts the decrease in investment due to global risk, that is, a risk that cannot be avoided whatever one does. The missing piece appears to be the contribution that emotions make to human decision making, besides cognitive factors as captured by CPT. More specifically, our results point at the influence of two emotions: anxiety and irritation. In the

[20] Further details of the factor analysis are left out to save space but can be obtained from the authors upon request.

psychological literature the related emotions of fear and anger are known to play an important role in the flight-or-fight response to threatening events, In case of anxiety a distinction has to be made between situation anxiety and decision anxiety. Whereas decision anxiety is generated by an individual's own decisions (here, investment), situation anxiety is induced by the setting that the individual is brought into or confronted with. Anxiety (like fear) is an avoidance type of emotion with a negative hedonic value and an action tendency to take less risk. This implies that anticipated decision anxiety will provide an additional stimulus to invest less. On the other hand, global risk appears to produce irritation (anger). This emotion too has a negative hedonic value but it differs from anxiety in being an approach type of emotion with an action tendency to take more risks. Because the setting of global risk adds situation anxiety as well as irritation and anger to the decision anxiety which plays a role in Baseline, the outcome in terms of average investment can in principle go in either direction, that is, it may lead to more or less investment depending on which action tendency is stronger. In this way we can explain our surprising finding of a decrease in investment. However, as the outcome of our additional experimental treatment with higher global risk (suggesting more risk seeking) foreshadows, higher average investment cannot be excluded, in general. What is of further interest in this context is that these counteracting emotional forces affect the shape of the distribution of investment, from an inverted-U shape to a U-shaped distribution. Incidentally, this demonstrates a limitation of the common procedure to offer subjects binary choices, which cannot reveal such an effect. The importance of anger-like emotions, furthermore, shows the restrictiveness of existing theoretical models focusing on anxiety only.

Related studies. In their taxonomy of dynamic choice problems, focusing on the well-known common ratio effect, Cubitt et al. (1998) consider some cases that bear a relationship with our global risk problem. The relationship is due to the introduction of a common factor (a loss probability common to all available options) at a particular stage of the decision problem. More particularly, these problems concern a binary choice between a safe option and a risky option with either the resolution of the common factor risk taking place before the choice is made ('prior lottery' problem) or after this choice is made but *before* the risk of the risky option is resolved ('precommitment' problem).[21] Note that in our case subjects are not restricted to a binary choice while the resolution of the global risk takes place *after* the risk of

[21] Using fig. 1, in case of the 'prior lottery' the resolution of the common factor (global) risk is located to the left of the rectangle in the figure, while in case of 'precommitment' the location is between the rectangle and the circle (with, in either case, no continuation if the risk materializes).

the risky project is resolved. Interestingly, Cubitt et al. do not find a significant behavioral difference between the precommitment problem and the 'scaled-up' problem without a common factor; this result is in line with the original finding of Kahneman & Tversky (1979).[22] In fact, there is a good deal of evidence that the common ratio effect (more risk seeking) disappears in the precommitment problem (Davis & Holt, 1993; Starmer, 2000). This is imputed to the greater transparency in the precommitment problem compared to the reduced lottery, where the common factor is multiplied by the choice probabilities and for which the common ratio effect is found. It seems that subjects are able to cognitively isolate the common factor in the precommitment problem, as proposed by Kahneman & Tversky (1979).

However, from this vantage point our, say, *post lottery* results are hard to explain, because in our design the global risk or common factor seems very clearly separated from the investment game (see table 1 and the Instructions in Appendix B). Therefore, it seems interesting to investigate whether in the precommitment problem emotions may have caused the absence of the common ratio effect. We offer three possible explanations.

Firstly, in these experiments the size of the global risk is in the range of our Global Risk High treatment, where we found no significant difference in the average investment level compared to Baseline (which is similar to the scaled-up problem). Thus, the explanation in terms of emotions that we offered for this case may also be relevant for the precommitment problem. Note, however, that our findings concerning Baseline and Global Risk High differed in several respects, related to the shape of the distribution of investment, which cannot be observed for the precommitment problem because of the restriction to binary choices.

Secondly, in this case hope instead of anxiety may have been primarily induced by the global risk. That is, hope to get successfully through the stage where the global risk is resolved, to enter the stage where the return on investment is determined. Whereas acute anxiety motivates to reduce risks and affects the way information is processed, no such clear biases appear to be associated with hope (Lazarus, 1991, 1999). If so, the experience of hope may not disturb the cognitive assessment of risks in any systematic way. According to Ortony et al. (1988) the difference between hope and anxiety is that the former is elicited by being pleased about the prospect of a desirable event while the latter is triggered by being displeased about the prospect of an undesirable event. Now, if in the precommitment problem subjects

[22] They do find a significant difference, though, between 'precommitment' and 'prior lottery', with more risk taking in the former.

focus more on the desirable aspect of going to the next (investment return) stage than on the undesirable aspect of not going to that stage, hope rather than anxiety will be elicited.

Finally, it may be that the risk of no continuation is sufficient to induce acute anxiety. The related action tendency to take less risk, however, may be counteracted by the influence of another (anticipated) emotion: regret.[23] Because in the precommitment problem there is a chance that the consequences of one's investment choice will not be revealed at all, less negative emotion due to regret may be anticipated than in the scaled-up problem. This would induce individuals to take more risk in the precommitment problem. If these two opposite forces more or less balance, the net result is that behavior will not be different.[24]

Topics for future research. Examining risk behavior under different affective conditions, focusing on specific emotions (e.g. regret or hope) while keeping in mind that decisions themselves may generate emotions (like decision anxiety), would seem to constitute an interesting avenue for future research. For example, as Caplin & Leahy (2001) pointed out in their theoretical paper, taking account of anxiety may help explain the equity premium puzzle. Our results provide a first empirical step in that direction, by showing that investment is accompanied by higher psychic costs. With regard to forward looking emotions such as fear and anxiety, one important question is what happens if the size of the global risk would be different from the values (1/3 and 2/3) studied in this paper. Using a very small probability of global risk might be an interesting extension. It might perhaps shed more light on the issue (raised by a referee) to what extent the observed impact of global risk could be due to an increase in the complexity of the decision problem. If, compared to Baseline, investment behavior would not be affected by such a small probability one might conclude that the increased complexity of the decision problem is not driving the results. On the other hand, from an emotional point of view it is possible that decisions are more sensitive to the possibility than to the probability of a negative outcome. In that case, raising the probability of losing everything from zero to some small positive number might even have a larger effect than changes within some midrange. In any case, the different results obtained for GRH compared to GR *vis-à-vis* BL suggest that it cannot be complexity alone that plays a role.

[23] On regret, see Zeelenberg et al. (1999) and Camille et al. (2004).

[24] Acute anxiety may also be the triggered in experiments applying the random lottery incentive system. With this procedure a random draw after a decision task involving a sequence of lotteries determines which lottery is played for real, which creates a layer of uncertainty. Incidentally, this may explain why Loomes (1991) finds a reverse common ratio effect in his experiment, concerning reduced lotteries, where this procedure is applied.. Another, more complicated choice study finding a reverse common ratio effect is Cubitt & Sugden (2001).

Another issue worthwhile to be investigated is to what extent 'cooling off' is possible if a decision can be delayed. In many situations people do not immediately have to make a decision. By postponing the decision emotions might perhaps cool off. On the other hand, it may very well be the case that emotions would show up (again) once one actually has to make the decision.

Regarding the behavioral consequences of anxiety, an interesting topic concerns the temporal pattern of this emotion. Psychological evidence suggests that the emotional intensity is U-shaped with respect to time. The initial reaction of an individual to some salient threat is generally intense anxiety which then decreases for a while up to some point where the anticipation of the threatening event fuels the emotion again (Loewenstein et al., 2001). This would suggest that the behavioral effects are particularly likely to show up directly after an individual learns about the threat and immediately prior to the realization of the threat, with perhaps little or no effects in between.

Finally, an interesting extension would be to allow for leveraged investment, which could potentially change the role of affect in investment. Empirically, this issue seems very relevant as investors, such as hedge funds or private equity houses, use large sums of borrowed (cheap) money to finance their investments.[25]

[25] In this context, it seems worth noticing that it appears to matter for investment whether experimental subjects first have to earn their working money (through a real effort task) or receive it as an endowment from the experimenter. An earlier version of this paper − which is available on request − contains the results of such a 'real effort' treatment, showing a negative effect on investment.

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Appendix A: Analyzing Global Risk

In this appendix we will analyze more formally the choice problems represented by figs. 1 and 2 in the paper. First of all, note that because the global risk (1–p) equally applies to the chance nodes 2 and 3 in fig. 2, investment should not be influenced by the size of this risk in case of an expected utility maximizer. Furthermore, because marginal utility can be assumed to be more or less constant over small changes in wealth (cf. Rabin, 2000) and the expected return from investment (½ p(z + 1.5x) + ½ p(z – x)) is positive for any p > 0, EU with wealth as an argument would predict investment to concentrate at x = z.

We now turn to RDU and CPT, using the decision tree presented in fig.2. Suppose first that reduction of compound lotteries holds, so that successive probabilities in a decision tree are multiplied (Machina, 1989). With *reference point 0*, both RDU and CPT evaluate the lottery (z + 1.5x, p/2; z – x, p/2; 0, 1–p) as $\pi_1 U(z + 1.5x) + \pi_2 U(z - x) + \pi_3 U(0)$, where $\pi_1 = w(p/2)$, $\pi_2 = w(p) - w(p/2)$, and $\pi_3 = 1 - w(p)$ for a probability weighting function w. Using the first-order derivative, people do not want to reduce an investment x if the following condition holds:

$$\frac{U'(z + 1.5x)}{U'(z - x)} \geq \tfrac{2}{3}\,\frac{\pi_2}{\pi_1} \qquad (1)$$

Without global risk (that is, p = 1), $\pi_1 = w(p/2) = w(½) \approx 0.42$ on average (Tversky & Kahneman, 1992), and w(p) = 1, so that $\pi_2 = 0.58$. Then, the RHS of (1) equals 0.92, which implies that with more or less constant marginal utility (i.e., LHS ≈ 1) all money would be invested: x = z. However, using a power utility function – as most empirical studies of RDU and CPT do (Wakker & Zank, 2002) – an interior solution may be obtained. For example, with $U(y) = y^\alpha$ and α = 0.88 (Tversky & Kahneman, 1992) we get x = 0.29z as investment level.[26] But what happens under global risk? If p becomes smaller, then, using the typical empirical finding of an inverse-S probability weighting function, π_1 will become relatively larger and π_2/π_1 will decrease, making the RHS of (1) smaller. Consequently, the prediction is

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[26] Holt and Laury (2002) mention a number of estimates of constant relative risk aversion (1–α) centered around the 0.3-0.5 range, implying an even lower investment level. With a CARA utility function $U(y) = 1 - e^{-ry}$ we get x = 0.033/r, with r the coefficient of absolute risk aversion. Hartog et al. (2002) present three estimates of this coefficient (in guilders), one of which (r = 0.00154) gives an interior solution (x = 21.43) if z = 30 as in the experiment. The other two estimates would imply extreme investment (x = 30), as holds for the negative mean and median estimates (again in guilders) presented in Pennings & Smidts (2000).

that global risk will stimulate investment.[27] In qualitative terms, a small chance of winning enhances risk seeking.

Consider next CPT with *reference point z.* Then, only the highest outcome (z + 1.5x) is a gain, while the other outcomes (z – x, and 0) will be perceived as losses. In addition to the distinction of a reference point, CPT differs from RDU by incorporating loss aversion and different weighting functions for gains (w^+) and losses (w^-). Then, condition (1) holds in the following sense: $\pi_1 = w^+(p/2)$ and $\pi_2 = \lambda(w^-(1–p/2) – w^-(1–p))$, where λ is the loss aversion parameter.[28] The empirical predictions are the following. Without global risk, $w^+(p/2) = w^+(1/2) \approx 0.42$ while $w^-(1–p/2) – w^-(1–p) = w^-(1/2)$ is bigger but will not exceed 0.5 by much. In the absence of loss aversion (that is, $\lambda = 1$) this results in a greater stimulus to invest, compared to a reference point of 0, because the RHS of (1) will be lower. On the other hand, with $\lambda \approx 2$ as the literature suggests, the RHS of (1) will now be larger than 1 implying a smaller incentive to invest. To study the effect of increasing global risk (decreasing p), we first rewrite the RHS of (1) as

$$2/3 \times \lambda \times \frac{(w^-(1–p/2) – w^-(1–p))/(p/2)}{w^+(p/2)/(p/2)}$$

where the numerator shows the average increase of w^- over the interval [1–p, 1–p/2] and the denominator the average increase of w^+ over the interval [0, p/2]. If p gets smaller, then, with an inverse-S probability weighting function, the denominator becomes bigger, relative to the numerator. At first, the increase of w^- over the interval [1–p, 1–p/2] becomes smaller because the interval is moving to the middle of [0, 1] where w^- is shallow. If p gets very small then the interval [1–p, 1–p/2] moves closer to the extreme 1, and the average increase of w^- may again become larger. However, even then the increase of w^+ over [0, p/2] will be larger because the arguments of w^- stay a bit away from the endpoint 1. Consequently, with the RHS of (1) becoming smaller, the prediction is that increasing global risk will enhance investment.

So far we have assumed that reduction of compound lotteries holds. Another popular assumption is that people substitute certainty equivalents at nodes and then calculate backwards (Segal, 1990). The evaluation of investment x then is: $\tau_1 \times \rho_1 U(z + 1.5x) + \tau_1 \times (1–\rho_1)U(0) + \tau_2 \times \rho_2 U(z – x) + \tau_2 \times (1–\rho_2)U(0)$. Here, ρ_1 (ρ_2) is the decision weight of the upper (lower) p-branch of the decision tree in fig. 2 when doing the certainty equivalent substitution

[27] Note that if a power weighting function is used for w, global risk will not affect the level of investment. This is easily seen by rewriting the RHS of (1) as $^2/_3(w(p)/w(p/2) – 1)$.
[28] This is easily derived, rescaling U(z) = 0.

at the upper (lower) chance node 2 (3), and τ_1 (τ_2) the decision weight of the upper (lower) ½-probability branch at the left chance node. Under RDU and CPT with *reference point 0* these parameters are independent of x. Then, using the first-order derivative, people do not want to invest less if the following condition holds:

$$\frac{U'(z+1.5x)}{U'(z-x)} \geq \tfrac{2}{3}\,\frac{\tau_2}{\tau_1} \times \frac{\rho_2}{\rho_1} \tag{2}$$

where $\rho_1 = \rho_2 = w(p)$, $\tau_1 = w(½)$ and $\tau_2 = 1 - w(½)$. Consequently, the RHS of (2) is independent of p, which means that global risk does not affect investment. Under CPT with *reference point z*, the situation is more complex. In that case, the lower chance node 3 is processed as a loss, while $\rho_2 = \lambda(1 - w^{-}(1-p))$ and $\tau_2 = \lambda w^{-}(½)$. When folding back at the upper chance node 2, the upper branch yielding z + 1.5x is a gain and $\rho_1 = w^{+}(p)$. The upper ½-probability branch at the left chance node 1 can be processed as a gain or a loss, depending on whether the upper lottery is more or less favourable than z. At the critical probability (where this lottery is equivalent to z) decreasing p leads to a sudden λ-times more weighting, at node 1, of the upper ½ branch, which will enhance investment. Thus, at this critical probability it may happen that decreasing p (increasing global risk) leads to more investment. Furthermore, as increasing x reduces the critical probability, while a higher p induces lower investment and increases the critical probability, there is a tendency for x to reach a level where the probability is critical. Above and below the critical probability, the parameters ρ_1, ρ_2, τ_1, and τ_2 are independent of x, and ρ_2/ρ_1 varies proportionally with $\lambda(1 - w^{-}(1-p))/w^{+}(p)$, which is not likely to vary much with p under the usual assumption of an inverse-S relationship for w^{+} and w^{-}. For, in that case, w^{-} is approximately the dual of w^{+} (Tversky & Kahneman, 1992). Hence, the prediction is that outside the critical probability global risk will not affect investment much.

Appendix B: Announcements and Instructions (translated from Dutch)

What follows are the oral announcement of the working money, the written announcement of the global risk in the Global Risk treatment, and the written instructions and payoff table concerning the investment game (used in all treatments). The written announcement and instructions were also read aloud.

Announcement of working money (before instructions)

In today's experiment every participant receives an amount of money of 30 guilders. These 30 guilders are your working money in the experiment. With the working money you can earn money, but it is also possible that you lose money. In any case, you will never lose more than 30 guilders. If you earn more than 30 guilders, then the difference will be paid out to you after the experiment (and you can keep the working money). If you earn less than 30 guilders, you have to pay the difference back to us (and you can keep what is left of the working money). The envelopes containing 30 guilders are now being distributed. We ask you to open the envelop en check its content. Thereafter you receive further instructions.

Announcement of global risk (Global Risk treatment)

In phase 4 of this experiment there is a chance of 1/3 that you will lose *all* your earnings. With this announcement every participant has received a red die. Part of the payment procedure of phase 4 is that every participant will be asked to throw this die one time under supervision. If the die shows a 5 or 6, then you will lose **all your earnings**. If the die shows a 1, 2, 3, or 4, then you will keep all your earnings. Note that your earnings in the experiment depend on the decision that you will take in phase 2.

[The four phases in this treatment are: (1) announcement about earnings, (2) instructions and decision with respect to working money, (3) return of projects, and (4) payment procedure.]

Instructions investment game and payoff table (all treatments)

Information about projects

In this phase you have to make a single decision concerning your working money. You have to allocate the 30 guilders that you received over two projects. These projects are denoted as A and B. You just received two cups with the letters A and B. The cup with the letter A represents project A and the cup with the letter B project B. For each guilder that you put in project A you will receive one guilder. Thus, project A always gives a certain return. For the amount that you put in project B the following holds. With probability one half (0.5) you will lose this amount and with probability one half (0.5) you will receive two and half (2.5) times this amount.

You can allocate the working money in whole guilders over the cups A and B in any possible combination that sums up to 30. The table below shows for each possible combination that you can choose the returns and corresponding probabilities. We will later give some examples to illustrate this table.

When you have allocated the working money over the projects A and B, you have to record your decision on the enclosed "Form". On this form you indicate how much money you have put in project A and how much money in project B. You also have to fill in your table number on this form. Once you have completed the form, the allocation of your working money over A and B cannot be changed any more.

In the next phase the return of project B will be randomly determined. Each participant has just received a white die. In the next phase everyone will be asked to throw this die a single time under supervision. If the die shows 1, 2, or 3, you will receive two and half (2.5) times the amount that you put in project B. If the die shows 4, 5, or 6, you will lose the amount that you have put in project B.

Money in Project		**Certain return**	**Probability of 0.5 of an additional return of**
A	**B**		
0	30	0	75
1	29	1	72.50
2	28	2	70
3	27	3	67.50
4	26	4	65
5	25	5	62.50
6	24	6	60
7	23	7	57.50
8	22	8	55
9	21	9	52.50
10	20	10	50
11	19	11	47.50
12	18	12	45
13	17	13	42.50
14	16	14	40
15	15	15	37.50
16	14	16	35

17 13	17	32.50
18 12	18	30
19 11	19	27.50
20 10	20	25
21 9	21	22.50
22 8	22	20
23 7	23	17.50
24 6	24	15
25 5	25	12.50
26 4	26	10
27 3	27	7.50
28 2	28	5
29 1	29	2.50
30 0	30	0