# DISCUSSION PAPER SERIES

No. 5451

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Ronald Bosman and Frans van Winden

***INDUSTRIAL ORGANIZATION***

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Available online at: www.cepr.org/pubs/dps/DP5451.asp

*ISSN 0265-8003*

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**Ronald Bosman,** De Nederlandsche Bank
**Frans van Winden,** University of Amsterdam and CEPR

Discussion Paper No. 5451
January 2006

Centre for Economic Policy Research
90–98 Goswell Rd, London EC1V 7RR, UK
Tel: (44 20) 7878 2900, Fax: (44 20) 7878 2999
Email: cepr@cepr.org, Website: www.cepr.org

CEPR Discussion Paper No. 5451

January 2006

# ABSTRACT

## Global Risk, Investment and Emotions*

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 classical 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. We also find that people invest less if own earnings are at stake, compared to money obtained as an endowment.

JEL Classification: A12, C91, D80 and G11
Keywords: dynamic choice, emotions, global risk, investment and real effort

Ronald Bosman
Economist
De Nederlandsche Bank
PO Box g8
1000AB Amsterdam
THE NETHERLANDS
Tel: (31 20) 524 5772
Fax: (31 20) 524 2506
Email: r.a.j.bosman@dnb.nl

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Frans van Winden
CREED, Department of Economics
E / 6th floor / 604
University of Amsterdam
Roetersstraat 11
1018 WB Amsterdam
THE NETHERLANDS
Tel: (31 20) 525 4251
Fax: (31 20) 525 5283
Email: f.a.a.m.vanwinden@uva.nl

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* This paper is part of the Marie Curie Research Training Network ENABLE (MRTM-CT-2003-505223). It is a completely revised and extended version of a paper that circulated before under the titles ‘Global risk, effort, and emotions in an investment experiment’ and ‘Anticipated and experienced emotions in an investment experiment’. The initial research for this paper was carried out within the EU-TMR Research Network ENDEAR (FMRX-CT98-0238). At the time of running the experiment Ronald Bosman was affiliated with CREED. We are especially grateful to Peter Wakker for his contribution to the theoretical analysis and his comments on the paper. Furthermore, we thank Alexander Gattig, Theo Offerman, Abdolkarim Sadrieh, Bodo Vogt, and Marcel Zeelenberg for useful remarks and suggestions. Also, comments by participants of the ENDEAR workshop in Barcelona, the Steyr meeting of the MacArthur Research Network on Norms and Preferences, the ESA conferences in Barcelona and Boston, the TIWODM workshop in Tuscon, and at seminars in Copenhagen, Erfurt, Jena, Oxford, Los Angeles (UCLA), and The Hague (CPB) are gratefully acknowledged.

Submitted 19 December 2005

## 1. Introduction

We investigate a novel dynamic choice problem in an investment experiment where emotions are measured through self-reports. The choice problem concerns the distribution of an amount of money over a safe option and a risky option when there is a "global risk", that is, a chance 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 classical Expected Utility or by its main contenders Rank-Dependent Utility and Cumulative Prospect Theory. An explanation is offered by taking emotions into account, using the emotion data from the experiment and recent psychological findings.

To study the behavioral response to a global risk is not only of theoretical interest. Global terrorism and political risk are phenomena that seem to make our study also empirically relevant. 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).[1] In general, of course, such risks may lead to the export 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.[2]

Another investment related aspect of our decision problem is that we have subjects 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 the literature.[3] In this context, we study whether it makes a difference if the money is first earned by spending real effort or simply received as an endowment. There is some similarity here with the different positions of managers and owner-entrepreneurs. In large organizations investment generally takes place via the entitlement of managers to the use of a budget that does not necessarily bear a strong

[1] A problem with field studies is that global (political) risk is hard to isolate. Moreover, these studies typically rely on cross-sectional data of countries that differ in many important ways (political system, tax regime, access to world markets, etc). 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.
[2] 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.
[3] An exception is Loomes (1991).

relationship with the manager's own past effort, in contrast with the owner-entrepreneur of a small business. To the extent that our experiment is valid in this respect, our finding that effort has a *negative* effect on investment has some relevance for policy since entrepreneurial activity is considered to be a significant factor in economic growth (see e.g. Libecap, 1999). To the best of our knowledge this is the first experimental study investigating this issue.[4]

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.

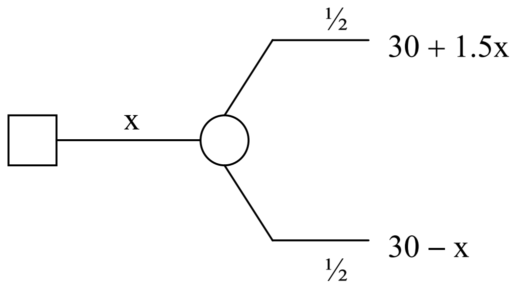
# 2. Theory and experiment

## 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.

[4] Boylan & Sprinkle (2001) experimentally investigate the effect of earned versus endowed income in the sphere of taxation and compliance. They find that when income is earned subjects respond to a tax increase by reporting more taxable income, which can be seen as evidence of more risk-aversion.



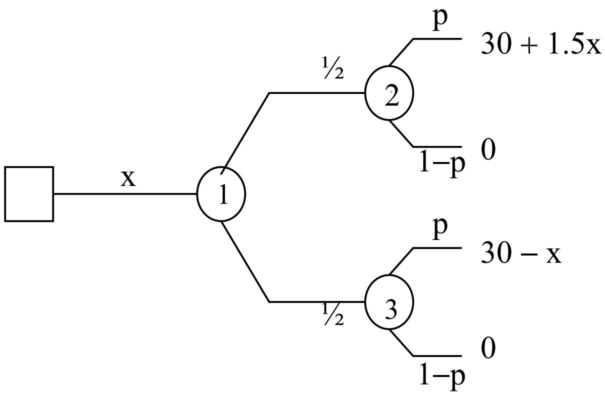




Fig. 1. Decision tree for Baseline Fig. 2. Decision tree for Global Risk

Our theoretical analysis of these cases focuses on classical Expected Utility (EU), Rank-Dependent Utility (RDU), and Cumulative Prospect Theory (CPT).[5] The following predictions are obtained (see Appendix A, for a more formal analysis)[6].

MAIN PREDICTION: *Classical 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, classical EU predicts that investment will concentrate at x = z, while empirical applications of RDU and CPT allow for non-extreme investment.

**Baseline versus Real Effort**

The only difference between Real Effort and Baseline is that participants in the former experimental treatment first have to earn their money by doing an individual decision-making task on the computer, before any information about the subsequent part of the experiment (the investment game) is provided to them.

Theoretically, EU and RDU predict no change in investment behavior if earned money instead of an endowment is at stake, because bygones are bygones in these theories. The same prediction holds for CPT, unless Real Effort induces a change in reference point. If more

[5] 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.

[6] 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.

subjects would now take z instead of 0 as reference point, a shift towards less risk seeking (less investment) would be predicted by this theory.

Unfortunately, there is no accepted theory of reference points that can be relied on for greater specificity. A prediction in this same direction of less investment can be obtained from the house money effect, which may be related to mental accounting (Thaler, 1985; Thaler & Johnson, 1990). If participants in Baseline perceive the money they are endowed with as a windfall gain, then this effect would predict relatively more risk seeking in this treatment (see also Keasey & Moon, 1996, and Boylan & Sprinkle, 2001).[7]

## 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. 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), 29.0 in Global Risk (GR), and 34.3 guilders in Real Effort (RE). The whole experiment took about 45 minutes (except for RE , which took half an hour extra).

We will first briefly discuss the procedures of Baseline and next indicate in which way the other experimental treatments differed. A summary of the sequence of events in the different treatments is given in table 1. 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 can earn more money but, possibly, also lose money. If their 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

[7] Sunk-cost effects (Thaler, 1980; Zeelenberg & van Dijk, 1997) do not seem to be relevant here because subjects were already compensated for their opportunity costs in Real Effort. According to Thaler & Johnson (1990), a prior loss induces risk seeking if the possibility exists to break even in terms of some reference point. When such a possibility does not exist, prior losses typically induce risk aversive behavior. However, it is unlikely that subjects in Real Effort perceived themselves in a loss position because their earnings were about twice as high as what they could have earned elsewhere.

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.[8] 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** | **Real Effort** |
|---|---|---|
| (1) 30 guilders in cash | (1) 30 guilders in cash | (0) *real effort task* |
| (2) instructions | (2) *announcement global risk* | (1) 30 guilders in cash |
| (3) allocation decision | (3) instructions | (2) instructions |
| A: sure return | (4) allocation decision | (3) allocation decision |
| B: risky return | A: sure return | A: sure return |
| (4) emotion measurement | B: risky return | B: risky return |
| (5) outcome risk B | (5) emotion measurement | (4) emotion measurement |
| (6) payment | (6) outcome risk B | (5) outcome risk B |
| | (7) *outcome global risk* | (6) payment |
| | (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).

[8] About half of the subjects in the BL experiment received the question concerning experienced emotions at the beginning of the experiment before they received the instructions (but after the reception of the envelope).

The only difference between Real Effort and BL concerns the way in which the 30 guilders are obtained. In RE this money is not given to subjects but has to be earned in advance by doing a computerized task. Subjects receive the instructions of the investment game after they have completed the task. The task is an individual two-variable optimization task that takes about 30 minutes (see van Dijk et al., 2001, for greater detail). It consists of 10 periods, where in each period subjects have to search for a maximum value. This maximum, which varies over the periods, can be imagined as the top of a mountain. The payoff for a period is related to the distance from the top at the end of the period, with a maximum of 3 guilders. The time limit has been chosen such that (almost) all subjects are able to find the maximum value within this limit.[9] Upon completion of the effort task subjects receive an envelope with their earnings in cash. Thereafter RE continues in precisely the same way as BL.

Emotions are measured through self-reports (Robinson & Clore, 2002). 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.[10] 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. Results

Fig. 3 shows the distribution of investment in the risky project in Baseline. Investment ranges from 7 to 30 guilders, with large spikes at 20 (the mode) 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 classical EU. A majority of the subjects (75%) appears to be risk

[9] Only one subject in RE earned less than the maximum amount of 30 guilders (namely, 15 guilders). In the analysis, we have multiplied this subject's relative investment (investment/earnings) by 30.

[10] The reason why we did not measure emotions before the decision is that we wanted to avoid any effect on the subsequent choice or the emotion measure after the decision since 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.

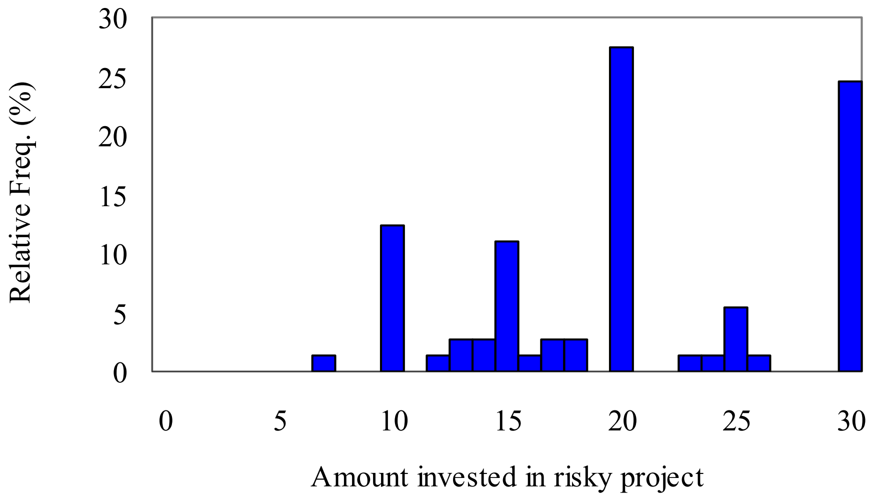



Fig. 3. Investment in Baseline (n = 73)

averse since they invest only part of their money in the risky project. The other 25% of the subjects can be seen as either 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).[11]

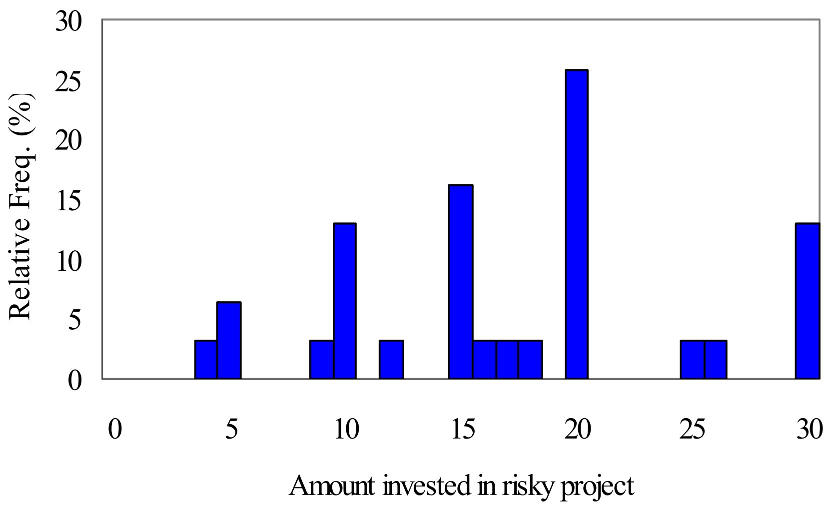



Fig. 4. Investment in Real Effort (n = 31)

[11] Holt & Laury (2002) find that the gender effect disappears in their high-payoff treatments.

We first compare the above outcomes with the investment decisions by subjects who had to work for their money instead of receiving it as an endowment. Fig. 4 shows the distribution of money allocated to the risky project in this case of Real Effort.

Although the shape of the distribution is again an inverted-U, and the mode is again at 20, the mass of the distribution has shifted to the left, that is, towards less investment. The average investment level has decreased to 17.2 (st. dev.: 7.43), which is about 15% less than the average in Baseline (Mann-Whitney test, p = 0.06)[12]. This leads to our first result.

RESULT 1: *If earned money instead of an endowment is at stake, there is a shift towards less investment.*

This result goes against the (no shift) prediction of EU and RDU. However, the outcome is in line with CPT if, compared to Baseline, relatively more subjects in Real Effort had a reference point of 30. If subjects in Baseline perceived their money endowment as a windfall gain then also the house money effect could explain our finding. We will return to this issue below, to see whether we can say more about the underlying motivational factors.

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. 5 shows the distribution of investment in GR.

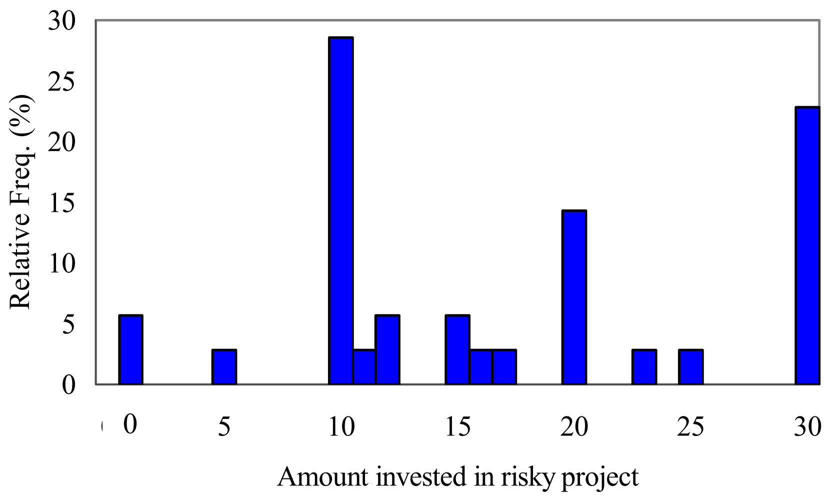



Fig. 5. Investment in Global Risk (n = 35)

[12] All tests in this paper are two-sided.

Clearly, a very different distribution shows up. First, instead of an inverted-U shape, a U-shaped distribution is now observed (Kolmogorov-Smirnov test, p = 0.02). Second, although there are again two larger spikes, in this case, besides the extreme one of 30, there is another one at 10 (instead of 20), which is now also the mode. Third, average investment in GR is 16.9 (st. dev.: 9.1), which is about 15% lower in comparison with BL (Mann-Whitney test, p = 0.04). 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 (Mann-Whitney test, p = 0.05). The next result presents our main finding.

RESULT 2 (MAIN FINDING): *Compared to Baseline, the average investment level 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 (an effect that can be explained by RDU and CPT).[13] 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. The underlying idea of this effect is that, as a decision heuristic, individuals may disregard components that alternatives share when mentally editing a decision problem. Although global risk is introduced in a way that would seem to facilitate isolation in the experiment, 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 hope to show that taking account of the affective component of decision-making may provide the solution.

## 4. Emotions can explain

### 4.1. Emotions

[13] 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 game and global risk in this way.

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 irritation 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). 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.[14]

In economics there have been several theoretical attempts to relate emotions to decision making under risk and uncertainty. 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) argue in favor of a risk-as-feeling hypothesis with greater explanatory power than current cognitive-consequentialist approaches. So far, however, economists have neglected to study experimentally the role of emotions in decision-making under risk or uncertainty.[15]

Our analysis will focus on the explanation of the effects of global risk. Before doing so, we first briefly discuss the greater risk aversion observed under Real Effort.

## 4.2. Affect and Real Effort

Because, psychologically, the degree of ego-involvement is higher if one has to earn one's money first, subjects in RE will feel more attached to their money than subjects in BL who simply received it. Ego-involvement is an important determinant of the intensity of, in particular, negative emotions (Lazarus, 1991). Consequently, if money is lost because of a bad investment outcome, the psychological cost (in terms of negative emotions like regret) will be higher in RE than in BL. On the other hand, the psychological benefit of a gain (in terms of positive emotions like joy) would not depend on effort so much. Thus, if subjects anticipate

[14] According to Robinson & Clore (2002), self-reports are the most common and potentially the best way to measure a person's emotional experience.
[15] More general discussions of the importance of emotions for economic theory are provided by Elster (1998) and Loewenstein (2000).

these emotions – for which substantial evidence exists[16] – one would expect them to invest less in RE, as we observed. Since our design concentrates on experienced anxiety related emotions, and not on anticipated regret or attachment, we can only add that we have indeed evidence of greater negative emotionality in case of RE. Even though investment is less in RE we find that subjects experienced more anger, after their investment decision but before the resolution of the investment risk, in this experimental treatment (Mann-Whitney test, $p = 0.05$), with anger being positively correlated with anxiety (Spearman rank-order coefficient: 0.51, $p = 0.00$).

## 4.3. 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 of experienced emotions such as anxiety or fear that may interfere with other motivational factors.[17] Psychological evidence shows that experienced anxiety 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 strongly suggests that experienced 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.

For later reference, we will refer to this type of anxiety as *situation anxiety* because it is generated by the situation an individual is in, and not by that individual's own decisions. The self-reports of the emotions subjects experienced immediately after their investment decision enable us to investigate more directly the role of anxiety and of other emotions in

[16] See Zeelenberg et al. (1999) and Camille et al. (2004)

[17] 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).

these decisions. The intensity scores of the emotions experienced in BL and GR are reported in table 2, where the reader should neglect the third column for the moment. The first column shows the scores for BL.[18] Among the negative emotions anxiety appears to be the most prominent one, followed by fear. But also some positive emotions obtain a relatively high score (in particular, hope). The second column of table 2 presents the data 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) |
| 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) | 3.26 (2.07) |
| 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) |

[a] Scores range from 1 (no emotion) to 7 (high intensity).

Comparing the mean 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 reveals that this mean score comparison is misleading. Firstly, there is a positive correlation between irritation and anxiety in GR (Spearman rank-order coefficient: 0.54, $p = 0.00$). This provides a first indication that anxiety plays a more prominent role in case of global risk, in particular, since irritation and

[18] The number of observations regarding emotions in BL is smaller than the number of observations concerning investment because about half of the subjects reported their emotions at the beginning of the experiment before any decision was made. 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, $p = 0.43$). The emotions reported at the beginning of the experiment are not further considered here because they turned out to have no predictive power for investment behavior (there is no significant correlation between investment and any of the twelve emotions that we measured; Spearman rank-order coefficient, $p > 0.10$). This may be due to the fact that the reporting took place before subjects received any instructions about the experiment (the investment game).

anxiety are not correlated in BL (p = 0.94). Secondly, one should take into account the possibility of a two-way relationship between investment and anxiety, in the sense that investment in its turn may generate anxiety. In fact, this is the type of anxiety referred by Caplin & Leahy (2001) when they argue that "the incorporation of anxiety into asset pricing models may help explain both the equity premium puzzle and the risk-free rate puzzle" (p.56). 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. Returning to the experiment, it stands to reason that the more one invests in the risky project, the more is at stake, and the more one may worry before the resolution of the risk. We will call this kind of anxiety *decision anxiety* because it is generated by an individual's own decision. While situation anxiety has received substantial attention in the psychological literature, decision anxiety has been neglected in both economics and psychology, notwithstanding its importance due to the implied additional psychic cost of risk taking.

To check whether indeed investment generates anxiety we have estimated an ordered logit model with as dependent variable the anxiety score and as 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). In other words, there is evidence of decision anxiety.[19]

RESULT 3. *Anxiety, measured after the investment decision but before the resolution of the investment risk, is positively related to the amount invested in Baseline, providing evidence of decision anxiety.*

This result has two important implications, which provide further support for the greater role of anxiety in GR. The first one is that the substantially lower investment level in GR would imply a lower level of decision anxiety in GR compared to BL. This can explain why similar mean scores for anxiety are observed, notwithstanding the presence of situation anxiety in GR. Due to the lower investment level, the similar scores in fact imply that anxiety per unit of investment has increased in GR. The second implication is that there is a two-way relationship between investment and anxiety in GR, which goes in opposite directions. Whereas

[19] 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 (see footnote 17).

investment is negatively related to situation anxiety, there is a positive relationship between investment and decision anxiety. Fig. 6 illustrates, where for simplicity linear relationships are assumed.

As a consequence of the counterbalancing effect of situation anxiety one should expect a less positive relationship between investment and anxiety in GR, because the anxiety scores are influenced by both kinds of anxiety. In fact, using again an ordered logit model, we find no relationship at all between investment and the anxiety scores in GR.[20]

RESULT 4. *Anxiety, measured after the investment decision but before the resolution of the investment risk, is not related to the amount invested in Global Risk. This can be explained by the counterbalancing of two forces: decision anxiety and situation anxiety.*

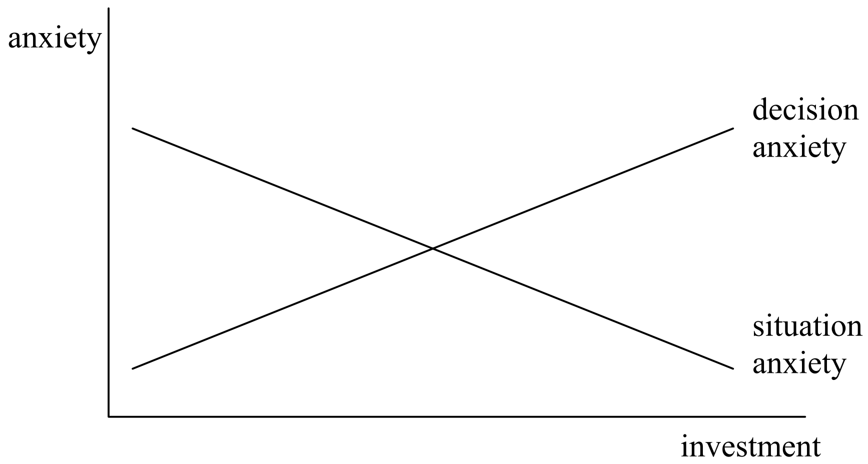



Fig. 6. Two-way relationship between anxiety and investment

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 go to the extreme of full investment? A clue is provided by the higher level of irritation observed in GR, reflecting a link between anxiety and irritability (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

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

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 irritation. Moreover, the observed correlation between anxiety and irritation shows that these conflicting action tendencies occur at the individual level.[21] To shed more light on this issue, we have run an extra experimental treatment with a larger global risk, which we discuss next.

## 4.4. Increasing the global risk

Instead of a global risk of 1/3, we will now investigate what happens if this risk is increased 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 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. 7 shows the distribution of investment in GRH.

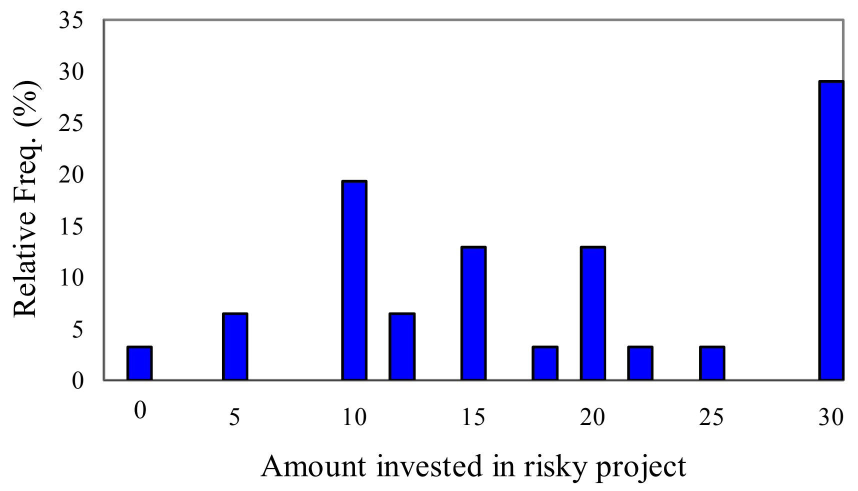



Fig. 7. Investment in Global Risk High (n = 31)

[21] 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).

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) is still smaller than investment in Baseline, but now no longer significantly so (Mann-Whitney test, p = 0.29). It would be misleading, however, to conclude that the behavioral outcomes are similar to BL. First of all, the average investment level is not significantly different from, and in fact a bit closer to, the average in GR (Mann-Whitney test, p = 0.51). Furthermore, the shape of the distribution of investment looks more similar to the one in GR. Finally, the range of investment is larger (showing low values) and the variance is higher (Mann-Whitney test, p = 0.01), again similar to what we observe in GR.

RESULT 5. *Increasing the global risk from 1/3 to 2/3 induces more risk seeking, which leads to an average investment level in between the levels of Baseline and Global Risk, but does not affect the shape of the distribution of investment as found for Global Risk, in a qualitative sense.*

To see whether affect can also 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, only irritation is stronger in GR, now in addition more anger and surprise is observed.[22] These results point at higher emotional arousal in case of GRH. Again, no difference in average experienced anxiety is found. However, anger and irritation are both highly correlated with anxiety (Spearman rank-order coefficients: anger: 0.90, p = 0.00; irritation: 0.78, p = 0.00), which provides indirect evidence of anxiety being more prominent in GRH than in BL. 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). In addition, they appeared to be marginally less happy (Mann-Whitney test, p = 0.07). Finally, as in GR, no correlation is found between the amount invested and the anxiety experienced after the investment decision.

[22] Anger and irritation show a correlation coefficient of 0.82 (Spearman rank-order coefficient, p = 0.00).

RESULT 6. *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 we have seen that anger is conducive to risk taking, Result 6 can explain why we observe a shift towards more investment in GRH, compared to investment in GR. Furthermore, the importance of anger in GRH, where the global risk is much higher, seems consistent with the view that certainty (next to individual control) is a central appraisal dimension distinguishing anger from fear (Smith & Ellsworth, 1985).

## 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, where in case of the former a distinction has to be made between situation anxiety and decision anxiety. Whereas decision anxiety is generated by an individual's own decisions (like investment), situation anxiety is induced by the setting that the individual is brought into or confronted with. Anxiety is an avoidance type of emotion with a negative hedonic value and an action tendency to take less risk. The former implies that anticipated decision anxiety will provide an additional stimulus to invest less. On the other hand, global risk appears to produce irritation. 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 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 (showing 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.

**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).[23] 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 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, in line with the original finding of Kahneman & Tversky (1979).[24] In fact, there is a good deal of evidence that the common ratio effect (more risk seeking) disappears in that case (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

[23] 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).

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

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 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 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. 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 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.[25]

**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

[25] 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).

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. Because decisions appear to be more sensitive to the possibility than the probability of a negative outcome, raising the probability of losing everything from zero to some small positive number may have a larger effect than changes within some midrange.

Another issue worthwile 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.

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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, classical EU 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) ≈ 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, $\pi_1$ will become relatively larger and $\pi_2/\pi_1$ will decrease, making the RHS of (1) smaller. Consequently, the prediction is

[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 $\lambda$ 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, $\rho_1$ ($\rho_2$) is the decision weight of the upper

[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.

(lower) p-branch of the decision tree in fig. 2 when doing the certainty equivalent substitution at the upper (lower) chance node 2 (3), and $\tau_1$ ($\tau_2$) 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:

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

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 $\rho_2 = \lambda(1 - w^-(1\text{–}p))$ 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 $\rho_1$, $\rho_2$, $\tau_1$, and $\tau_2$ are independent of x, and $\rho_2/\rho_1$ varies proportionally with $\lambda(1 - w^-(1\text{–}p))/w^+(p)$, 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: Instructions (translated from Dutch)

What follows are the 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).

### 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 |