# How does multiplicative background risk affect risk taking? Theoretical predictions and experimental evidence*

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September 7, 2021

**Abstract**

Preferences exhibit multiplicative risk vulnerability (MRV) if an individual behaves in a more risk-averse way after the introduction of any unfair multiplicative background risk. We examine risk-taking behavior in the standard portfolio problem and provide conditions for MRV under expected utility theory, cumulative prospect theory and rank-dependent utility. We conduct the first incentivized laboratory experiment to test the effects of multiplicative background risk on risk taking. We find that the propensity for MRV choices is heavily dependent on the shape of the background risk in our sample: the presence of a left-skewed multiplicative background risk increases risk taking by approximately 10%. A symmetric background risk does not lead to changes in risk-taking behavior compared to the situation without background risk. We do not find any statistical association between MRV and sociodemographic factors.

**Keywords:** Decision-making under risk · Lab experiment · Multiplicative risk vulnerability · Multiplicative background risk

**JEL Classification:** C81 · C90 · C91 · D81 · G11

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# 1 Introduction

Individuals are routinely exposed to multiple sources of risk, which has generated a growing literature on the effects of so-called background risk on behavior starting with Doherty and Schlesinger (1983), and later Gollier and Pratt (1996) and Eeckhoudt et al. (1996). Background risk can help resolve the equity premium puzzle (Weil, 1992) and matters for optimal consumption-saving decisions on incomplete markets (Zeldes, 1989; Gourinchas and Parker, 2002). In this paper, we provide new results on how the addition of a multiplicative background risk changes risk-taking behavior. Many settings can give rise to multiplicative background risk. Examples include (i) a random income tax rate due to legislative uncertainty, (ii) randomness in the purchasing power due to inflation risk, or (iii) random foreign exchange rates. Even though multiplicative background risk arises in various contexts, little is known about its effects on behavior.

Multiplicative background risk has unique effects on individuals' risk taking because of the way it interacts with the endogenous risk. Intuitively, it is not clear that the addition of a multiplicative background risk leads to less or more risk taking. When the background risk is additive, the volatility of the final wealth distribution is always the same for additive background risk conditional on the value of the endogenous risk. The realization of the endogenous risk only affects the location of the final wealth distribution. This is not true for a multiplicative background risk: the realization of the endogenous risk also affects the scale of the final wealth distribution. When the endogenous risk yields high outcomes, these are amplified by the multiplicative background risk; when the endogenous risk yields low outcomes, this scales down the uncertainty arising from the multiplicative background and limits the downside. As such, it is plausible that multiplicative background risk may as well encourage risk taking in certain situations. Given the multiplicative nature of the background risk, it also appears that the shape of the background risk may impact risk taking: a left-skewed background risk leads to more variation in relative terms in the bad state of the world and less in the good state of the world. Increasing the exposure to the endogenous risk leads to less wealth in the bad state of the world (and more in the good state of the world). This decreases absolute volatility in the bad state of the world more, the more left skewed the risk is. Accordingly, a more left-skewed multiplicative background risk may lead to more risk taking.

Existing literature has mainly concentrated on additive background risk. Gollier and Pratt (1996) call preferences risk vulnerable when individuals behave in a more risk-averse way after adding any unfair background risk to their wealth. Under expected utility, additive risk vulnerability places restrictions on the utility function that are satisfied by many commonly used functional forms. Guiso and Paiella (2008) construct a direct measure of absolute risk aversion from survey data and show that, in the cross-section, income uncertainty is positively associated with absolute risk aversion. In two laboratory experiments, Beaud and Willinger (2015) find that approximately 80% of choices are consistent with additive risk vulnerability.[1]

Existing theory is scarce and offers no clear predictions about the effect of multiplicative background risk on risk-taking behavior. In analogy to Gollier and Pratt (1996), Franke et al. (2006) call preferences multiplicative risk vulnerable (MRV) when individuals behave in a more risk-averse way after introducing an arbitrary independent multiplicative background risk that is undesirable. They then derive a necessary and sufficient condition for preferences to be MRV in the expected utility model. Due to its complexity, they also state simpler sufficient conditions, which place restrictions on the Arrow-Pratt coefficient of relative risk aversion. The class of hyperbolic absolute risk aversion (HARA) utility functions reveals that standard choices of preference parameters can lead to behavior that is either more or less risk-averse after the introduction of a multiplicative background risk. Unlike for additive background risk, no dominant pattern arises. To resolve this indeterminacy, we conduct the first incentivized laboratory experiment to investigate how multiplicative background risk affects risk-taking behavior in actuality.

In a first step, we summarize and extend the theoretical predictions about the effects of multiplicative background risk on risk taking under various theories of choice under risk. Specifically, we consider expected utility theory (EUT), cumulative prospect theory (CPT) and rank-dependent utility (RDU), and evaluate the decision situations that individuals face in the experiment. Under EUT, multiplicative risk vulnerability is determined by the monotonicity and curvature of relative risk aversion and by the comparison of relative risk aversion against unity. In the knife-edge case of constant relative risk aversion (CRRA), multiplicative background risk only affects welfare but not behavior. CPT mostly predicts an increase in risk taking after introducing multiplicative background risk for common parameterizations and reference points. RDU predicts less risk taking for a symmetric multiplicative background risk but more risk taking for a multiplicative background risk with negative skewness. Overall, RDU predicts the choices in our laboratory experiment best.

To isolate the effect of multiplicative background risk on behavior, we use a within-subject design where individuals take two investment decisions, one in the

[1] Lusk and Coble (2008) also conducted a laboratory experiment but found only weak evidence of risk vulnerability. They used a between-subjects design. The claim of risk vulnerability is intrapersonal, not interpersonal, making Beaud and Willinger's (2015) within-subject design better aligned with the theory of additive background risk.

presence of a multiplicative background risk and one in the absence of background risk. We can thus determine the role of multiplicative background risk for risk taking at the individual level, consistent with the theory of background risk. In the experiment, we use two types of background risk between subjects, a symmetric one and a left-skewed background risk with negative skewness. Both background risks have a mean of one to mute wealth effects and have the same variance. Ever since Golec and Tamarkin's (1998) paper, skewness has been recognized as an important driver of decision-making under risk.[2] Ebert and Wiesen (2011) provide evidence of skewness-seeking in the laboratory and relate it to downside risk aversion (see Menezes et al., 1980) and prudence (see Kimball, 1990). We find that the propensity for MRV choices is heavily dependent on the shape of the background risk in our sample: the presence of a left-skewed multiplicative background risk increases risk taking by approximately 10% while a symmetric background risk does not lead to changes in risk-taking behavior compared to the situation without background risk. We do not find any statistical association between MRV and sociodemographic factors.

The remainder of the paper is organized as follows. In section 2, we provide theoretical predictions of the effect of multiplicative background risk on risk-taking behavior in the standard portfolio problem for various models of choice under risk. Section 3 describes the experimental design. We present the results of the experiment in Section 4. A final section concludes.

# 2 Multiplicative background risk in the standard portfolio problem

## 2.1 Preliminaries

We first introduce the version of the standard portfolio problem that we will use in the experiment. Individuals receive an initial endowment $x_0$ and decide how to allocate it between a safe asset and a risky asset. We denote by $\delta \in [0,1]$ the fraction of the endowment invested in the risky asset. The individual thus decides to allocate $(1-\delta)x_0$ to the safe asset and $\delta x_0$ to the risky asset. The amount invested in the risky asset is subject to a binary return risk. With probability $p$ it increases to $k\delta x_0$ for a $k > 1$, resulting in a return of $k-1$. With probability $1-p$ the investment is lost. So the value of the individual's portfolio $\widetilde{x}(\delta)$ is given by

[2] Already Mao (1970) noted that, everything else equal, surveyed business executives express a preference for positive over negative skewness.

$x^+ = x_0 + (k-1)\delta x_0$ in the good state and by $x^- = x_0 - \delta x_0$ in the bad state,

$$\widetilde{x}(\delta) = \begin{cases} x^+ = x_0 + (k-1)\delta x_0 & \text{with probability } p, \\ x^- = x_0 - \delta x_0 & \text{with probability } 1-p. \end{cases}$$

To isolate the effect of multiplicative background risk on behavior, we compare individuals' optimal investment amounts in the standard portfolio problem with and without multiplicative background risk. The version described above does not include multiplicative background risk and serves as the control treatment, denoted by $C$. It corresponds to the investment game used by Gneezy and Potters (1997), Gneezy et al. (2009), Cohn et al. (2015), Imas (2016), and Cohn et al. (2017) and many others. In the other version, denoted by $B$, the value of the individual's portfolio is subject to a multiplicative background risk $\widetilde{y}$, which is independent of the return risk associated with the investment in the risky asset. For simplicity, we assume a binary background risk with values $y^+$ and $y^-$, resulting in a total of four possible outcomes for the individual:

$$x^+y^+ = (x_0 + \delta(k-1)x_0)y^+, \qquad x^-y^+ = (x_0 - \delta x_0)y^+,$$
$$x^+y^- = (x_0 + \delta(k-1)x_0)y^-, \qquad x^-y^- = (x_0 - \delta x_0)y^-.$$

Figure 1 presents both treatments side by side.


**Fig. 1:** Investment choice without multiplicative background risk (control treatment C) and with multiplicative background risk $\widetilde{y}$ (treatment B).

Let the individual's preferences over final wealth be represented by means of a preference functional $V$. Assuming unique solutions, the optimal fraction of the endowment invested in the risky asset is given by

$$\delta_C^* = \arg\max_{\delta \in [0,1]} V(\widetilde{x}(\delta))$$

in the absence of background risk (treatment $C$) and by

$$\delta_B^* = \arg\max_{\delta \in [0,1]} V(\widetilde{x}(\delta)\widetilde{y})$$

in the presence of the multiplicative background risk $\widetilde{y}$ (treatment $B$). We can then compare $\delta_C^*$ and $\delta_B^*$ to identify the effect of the multiplicative background risk on risk-taking behavior. When $\delta_C^* \geq \delta_B^*$, multiplicative background risk leads to less risk taking and strictly less if $\delta_C^* > \delta_B^*$. This behavior is consistent with multiplicative risk vulnerability. When $\delta_C^* = \delta_B^*$, multiplicative background risk has no effect on risk taking. For $\delta_C^* \leq \delta_B^*$, multiplicative background risk leads to more risk taking and strictly more if $\delta_C^* < \delta_B^*$. Such behavior is consistent with the reverse of multiplicative risk vulnerability. When preferences are MRV, then *any* multiplicative background risk leads to less risk taking whereas if preferences are the opposite of MRV, *any* multiplicative background risk leads to more risk taking. In practice, an individual's preferences may be neither MRV nor its opposite. Then, some multiplicative background risks increase risk taking while others reduce it. Therefore, we only focus on the effects of multiplicative background risk on behavior because it is conceptually impossible to confront individuals with all possible background risks in the laboratory.

**Definition 1.** *An individual makes a multiplicative risk vulnerable choice if* $\delta_C^* \geq \delta_B^*$. *The individual makes a multiplicative risk strictly vulnerable choice if* $\delta_C^* > \delta_B^*$, *an indifferent choice if* $\delta_C^* = \delta_B^*$ *and a multiplicative risk non-vulnerable choice if* $\delta_C^* < \delta_B^*$.

In the following, we first make theoretical predictions on how an individual determines ther optimal $\delta_C^*$ and $\delta_B^*$ in EUT, CPT and RDU. In CPT and RDU, we cannot infer any general predictions based on the shape of the utility function but require a numerical example to compute predictions. We choose the following numerical example which is identical to the decision situation in our experiment: we endow our subjects with $x_0$ = EUR 8.00 and let $k = 2.5$ and $p = 0.5$. In $B_{symm}$, we set $(y^+,y^-) = (1.4,0.6)$ and both outcomes are equally likely. In $B_{skew}$, we have $(y^+,y^-) = (1.2,0.2)$, where the probability of $y^+$ is 0.8 and the probability of $y^-$ is 0.2. Consequently, both the symmetric and skewed background risk have equal mean (1) and variance (0.16).

It is important to note that we only consider in-lab wealth $\widetilde{x}(\delta)$ in this analysis. Thus, we implicitly assume that individuals do not take real life wealth from outside the experiment into account and the argument of the preference functional $V$ is income rather than terminal wealth. This is in line with much of the theory on asset integration and risk taking. For instance, Andersen et al. (2018) find that the participants in their study only integrated a very small fraction of real life wealth into the experimental decisions. Fafchamps et al. (2015) similarly only observe a statistically insignificant and economically small effect of household assets on risk-taking in a sample with individuals from rural Ethiopia. While real life wealth from outside the experiment does not change the analysis within Cumulative Prospect

Theory due to the reference point-dependence, it does make a difference in Expected Utility Theory (EUT) and Rank-Dependent Utility (RDU). If we include out-of-lab wealth in the wealth argument within EUT such that the argument is terminal wealth, multiplicative background risk only affects the risky in-lab wealth, not the safe out-of-lab wealth. We refer to Appendix A for an analysis of optimal investment decisions within EUT and full asset integration.

## 2.2 Expected Utility Theory

In Expected Utility Theory (EUT), we assume that there exists a von Neumann-Morgenstern utility function $u$ with $u' > 0$ and $u'' < 0$ such that the individual's preference function over random wealth $\widetilde{x}(\delta) = x_0 + \delta(\widetilde{k} - 1)x_0$ is given by

$$V(\widetilde{x}(\delta)) = \mathbb{E}[u(\widetilde{x}(\delta))].$$

Following Franke et al. (2006), we define an additional utility function $U$ as

$$U(x) = \int_a^b u(xy)dG(y) = \mathbb{E}[u(x\widetilde{y})],$$

where $G$ denotes the cumulative distribution function of $\widetilde{y}$. Note that $U$ is also increasing and concave, as $u$ is. We can interpret the relationship between $u$ and $U$ such that an individual with utility function $u$, who faces the additional multiplicative background risk $\widetilde{y}$, behaves in the same way as another individual with utility function $U$ without any multiplicative background risk.

If an interior solution $\delta^* \in [0,1]$ to the optimization problem exists, then it follows easily that the optimal investment $\delta^*$ solves the following condition (Beaud and Willinger, 2015):

$$\frac{u'(x^-)}{u'(x^+)} = k - 1. \tag{1}$$

If $\frac{u'(x^-)}{u'(x^+)} > k - 1$ for $\delta = 0$, then $\delta^* = 0$. Similarly, if $\frac{u'(x^-)}{u'(x^+)} < k - 1$ for $\delta = 1$, then $\delta^* = 1$. To summarize, the optimal investment $\delta^*$ is given by (Beaud and Willinger, 2015):

$$\begin{aligned}
&\delta^* = 1 && \text{if } \frac{u'(x^-(1))}{u'(x^+(1))} < k - 1 \\
&\delta^* \in [0,1] && \text{if } \frac{u'(x^-(\delta^*))}{u'(x^+(\delta^*))} = k - 1 \\
&\delta^* = 0 && \text{if } \frac{u'(x^-(0))}{u'(x^+(0))} > k - 1
\end{aligned}$$

In the presence of the multiplicative background risk, decisions can be described by utility function $U$ rather than $u$. Thus, in the presence of multiplicative background risk, we end up with the same conditions with $u$ being substituted by $U$.

From Theorem 1 in Pratt (1964), we know that utility function $U$ is at least as risk-averse than utility function $u$ if and only if

$$\frac{u'(a)}{u'(b)} \leq \frac{U'(a)}{U'(b)} \quad \text{for all } a \leq b. \tag{2}$$

Note that $x^- < x^+ \Leftrightarrow \delta > 0$, i.e. it holds for the ratios $\frac{u'(x^-)}{u'(x^+)} > 1 \Leftrightarrow \delta > 0$ as well as $\frac{U'(x^-)}{U'(x^+)} > 1 \Leftrightarrow \delta > 0$. Moreover, due to concavity of both $u$ and $U$, the ratios are increasing in $\delta$. Thus, if $U$ is at least as risk-averse as $u$, we observe a multiplicative risk vulnerable choice, i.e. $\delta_B^* \leq \delta_C^*$. Equivalently, we can also formulate this in terms of the coefficients of absolute risk aversion, $r_A^u$ and $r_A^U$: we observe $\delta_B^* \leq \delta_C^*$ if

$$r_A^u(x) = -\frac{u''(x)}{u'(x)} \leq -\frac{U''(x)}{U'(x)} = r_A^U(x) \;\; \text{for all } x > 0. \tag{3}$$

To summarize, we get the following result, which is similar to Proposition 1 in Beaud and Willinger (2015)

**Proposition 1.** *If $U$ is at least as risk-averse as $u$ ($r_A^u \leq r_A^U$), the individual makes a multiplicative risk vulnerable choice ($\delta_C^* \geq \delta_B^*$).*

Note that if we could observe $\delta_B^* \leq \delta_C^*$ for *all* background risks $\widetilde{y}$ and *all* wealth levels $x$, this would imply $U$ to be at least as risk-averse as $u$, i.e. we obtain an equivalence in the previous proposition.

Franke et al. (2006) derives conditions on the utility function $u$ under which (3) holds. For this, it is useful to note that (3) is itself equivalent to

$$r_R^u(x) = -x\frac{u''(x)}{u'(x)} \leq -x\frac{U''(x)}{U'(x)} = -x\frac{\mathbb{E}[\widetilde{y}^2 u''(x\widetilde{y})]}{\mathbb{E}[\widetilde{y}u'(x\widetilde{y})]} = r_R^U(x) \;\; \text{for all } x > 0. \tag{4}$$

The derived conditions are closely related to the coefficient of relative risk aversion $r_R^u(x)$. While the necessary and sufficient condition given in Franke et al. (2006) is technical, they also provide more intuitive sufficient conditions on the coefficient of relative risk aversion. We recapitulate these conditions in the following corollaries. Let $F$ be the cumulative distribution function of $\widetilde{x}$.

**Corollary 1** (Franke et al., 2006)**.** *Suppose that $r_R^u(x)$ is convex and one of the following conditions holds for all $(x,y) \in Supp(F) \times Supp(G)$:*

1. *$r_R^u(xy) > 1$ and $r_R^u$ decreasing,*

*2. $r_R^u(xy) < 1$ and $r_R^u$ increasing.*

*Then (3) holds, i.e. the individual is multiplicative risk vulnerable.*

**Corollary 2** (Franke et al., 2006)**.** *Suppose that $r_R^u(x)$ is concave and one of the following conditions holds for all $(x,y) \in Supp(F) \times Supp(G)$:*

*1. $r_R^u(xy) > 1$ and $r_R^u$ increasing,*

*2. $r_R^u(xy) < 1$ and $r_R^u$ decreasing.*

*Then (3) holds, i.e. the individual is multiplicative risk vulnerable.*

Note that MRV does not hold for one of the most commonly used classes of utility functions in EUT: isoelastic utility functions $u(x) = \frac{x^{1-\eta}}{1-\eta}$ for $\eta \geq 0, \eta \neq 1$ ($u(x) = \log(x)$ for $\eta = 1$) which expresses constant relative risk aversion (CRRA). Then we have $r_R^u(x) = \eta$. Since $U(x) = \mathbb{E}[u(x\widetilde{y})] = \frac{x^{1-\eta}}{1-\eta}\mathbb{E}[\widetilde{y}^{1-\eta}]$, it follows that also $r_R^U(x) = \eta$.

### 2.3 Cumulative Prospect Theory

In cumulative prospect theory (CPT, Tversky and Kahneman (1992)), the preference functional has the following form

$$V(\widetilde{x}) = \sum_{i=0}^{n} \pi_i^+ \cdot v(x_i) + \sum_{i=-m}^{0} \pi_i^- \cdot v(x_i)$$

where $\pi^- = [\pi_{-m}^-, \ldots, \pi_0^-]$ and $\pi^+ = [\pi_0^+, \ldots, \pi_n^+]$ are decision weights derived from the probability weighting functions $w^- : [0,1] \to [0,1]$ and $w^+ : [0,1] \to [0,1]$:

$$\begin{aligned}
\pi_i^- &= w^- \left( \sum_{j=-m}^{i} p_j \right) - w^- \left( \sum_{j=-m}^{i-1} p_j \right), \text{ for } -m+1 \leq i \leq 0, \\
\pi_i^+ &= w^+ \left( \sum_{j=i}^{n} p_j \right) - w^+ \left( \sum_{j=i+1}^{n} p_j \right), \text{ for } 0 \leq i \leq n-1,
\end{aligned}$$

with $\pi_{-m}^- = w^-(p_{-m})$ and $\pi_n^+ = w^+(p_n)$, where $w^+$ and $w^-$ are strictly increasing functions with $w^+(0) = w^-(0) = 0$ and $w^+(1) = w^-(1) = 1$.

When deriving the optimal investment level, $\delta$, we assume a piecewise power value function

$$v(x) = \begin{cases} v^+(x) = (x - rp)^\alpha & \text{for gains, i.e., } x - rp \geq 0, \\ v^-(x) = -\lambda\,(rp - x)^\beta & \text{for losses, i.e., } x - rp < 0, \end{cases}$$

where $rp$ denotes the reference point, $\lambda$ measures the degree of loss aversion and $\alpha$ and $\beta$ shape how individuals value deviations from the reference point. As usual in CPT and PT, the question arises which reference point indviduals choose.

Without background risk, we assume that the initial endowment is most intuitive choice as reference point. In the presence of a background risk, however, there are several potential reference points which seem intuitive choices: again, the reference point could simply be the initial endowment $x_0$. Note that the endowment is not an attainable final outcome in the presence of the background risk: if the individual does not invest anything, she ends up either with $x_0 y^+$ or $x_0 y^-$. These two values could thus also serve as reference points, with the former being the "optimistic" reference point, and the latter being the "pessimistic" reference point (Beaud and Willinger, 2015). Hence, we include all three reference points into the numerical analysis. We follow Beaud and Willinger (2015) and choose Prelec's (1998) single parameter probability weighting function to derive the decision weights:

$$w_\theta(p) = \exp\left(-\left(-\log(p)\right)^\theta\right) \text{ for } p \in [0,1], \tag{5}$$

with $\theta^+ = 0.5$ for $w^+$ and $\theta^- = 0.65$ for $w^-$.

In Table 1, we provide results for investment decisions made according to common parametrizations in CPT with the symmetric background risk. We compare investment amounts with and without background risk to classify MRV choices. We utilize the three different reference points discussed above for the symmetric background risk as well as three different parameter choices for both the value function and the probability weighting function. We observe a higher investment in the risky asset with the background risk if the reference point equals the endowment ($rp = 8.00$) or in case of the optimistic reference point $rp = 11.60$. We only observe MRV decisions when we assume the pessimistic reference point ($rp = 4.80$). Note, however, that the investment in the risky asset predicted by CPT without background risk is substantially smaller than what is usually found in labratory experiments.

Table 2 displays the results for the skewed background risk. The table is set up analogously to Table 1 and results without background risk are naturally the same. With the skewed background risk, we predominantly oberserve non-MRV choices. The only exception is the low reference point $rp = 1.60$ in Panel A where individuals display the lowest degree of loss aversion and the lowest $\alpha$ and $\beta$-factors.

In summary, CPT mostly predicts non-MRV choices unless the reference point is pessimistic.

**Table 1:** Optimal investment within CPT: Symmetric Background Risk

| $\delta_C$ | $\delta_{B_{symm}}$ | | |
|---|---|---|---|
| $rp$= 8.00 | $rp$= 8.00 | $rp$= 4.80 | $rp$= 11.20 |
| **Panel A:** $\alpha = 0.2$, $\beta = 0.4$, $\lambda = 1$ | | | |
| 0.0047 | 0.2138 | 0.0004 | 1.00 |
| **Panel B:** $\alpha = 0.6$, $\beta = 0.9$, $\lambda = 2$ | | | |
| 0.0062 | 0.2541 | 0.0041 | 0.0220 |
| **Panel C:** $\alpha = 0.8$, $\beta = 0.88$, $\lambda = 2.25$ | | | |
| 0.0000 | 0.2846 | 0.0000 | 0.0155 |

*Notes:* This table provides numerical illustrations of the optimal investment amount according to cumulative prospect theory. We assume a piecewise power value function, $v^+(x) = (x - rp)^\alpha$ for gains, i. e., $x - rp \geq 0$, and $v^-(x) = -\lambda(rp - x)^\beta$ for losses, i. e., $x - rp < 0$, with loss aversion parameter $\lambda = 1$ (panel A), $\lambda = 2$ (panel B) and $\lambda = 2.25$ (panel C), and power coefficients $\alpha = 0.2$, $\beta = 0.4$ (panel A), $\alpha = 0.6$, $\beta = 0.9$ (panel B), and $\alpha = 0.8$, $\beta = 0.88$ (panel C). For probability weights, we use Prelec's (1998) single parameter function with parameters $\theta^+ = 0.5$ (gains) and $\theta^- = 0.65$ (losses).

**Table 2:** Optimal investment within CPT: Skewed Background Risk

| $\delta_C$ | $\delta_{B_{skew}}$ | | |
|---|---|---|---|
| $rp$= 8.00 | $rp$= 8.00 | $rp$= 1.60 | $rp$=9.60 |
| **Panel A:** $\alpha = 0.2$, $\beta = 0.4$, $\lambda = 1$ | | | |
| 0.0047 | 0.0720 | 0.0018 | 0.0287 |
| **Panel B:** $\alpha = 0.6$, $\beta = 0.9$, $\lambda = 2$ | | | |
| 0.0062 | 0.1199 | 0.3902 | 0.0183 |
| **Panel C:** $\alpha = 0.8$, $\beta = 0.88$, $\lambda = 2.25$ | | | |
| 0.0000 | 0.1602 | 0.6688 | 0.0034 |

*Notes:* This table provides numerical illustrations of the optimal investment amount according to cumulative prospect theory. We assume a piecewise power value function, $v^+(x) = (x - rp)^\alpha$ for gains, i. e., $x - rp \geq 0$, and $v^-(x) = -\lambda(rp - x)^\beta$ for losses, i. e., $x - rp < 0$, with loss aversion parameter $\lambda = 1$ (panel A), $\lambda = 2$ (panel B) and $\lambda = 2.25$ (panel C), and power coefficients $\alpha = 0.2$, $\beta = 0.4$ (panel A), $\alpha = 0.6$, $\beta = 0.9$ (panel B), and $\alpha = 0.8$, $\beta = 0.88$ (panel C). For probability weights, we use Prelec's (1998) single parameter function with parameters $\theta^+ = 0.5$ (gains) and $\theta^- = 0.65$ (losses).

## 2.4 Rank Dependent Utility

We also compute optimal investment amounts with and without background risk in Rank-Dependent Utility (RDU) Theory (Quiggin, 1982), where the preference functional has the following form

$$V(\widetilde{x}) = \sum_{i=1}^{n} \pi_i u(x_i).$$

The outcomes are ordered from worst to best: $x_1 \leq x_2 \leq \cdots \leq x_n$. $\pi_i$ are decision weights derived from a probability weighting function $w : [0,1] \to [0,1]$:

$$\pi_i = w\left(\sum_{j=1}^{i} p_i\right) - w\left(\sum_{j=1}^{i-1} p_i\right)$$

with $w(0) = 0$ and $w(1) = 1$. $u$ denotes a von Neumann-Morgenstern utility function. To isolate the effect of probability weighting, we use the isoelastic utility function $u(x) = \frac{x^{1-\gamma}}{1-\gamma}$. Throughout this example, we assume $\gamma = 0.75$ as in Beaud and Willinger (2015). Note that without probability weighting, the utility function would imply identical investment choices $\delta_B^* = \delta_C^*$ as discussed in the previous section. Probability weights are calculated according to (5) with a single choice of $\theta$ as RDU does not include a reference point. Without background risk, rank-dependent utility is given by

$$V(\widetilde{x}(\delta)) = w(0.5,\theta)u(x^-) + [1 - w(0.5,\theta)]u(x^+).$$

Taking the first derivative with respect to $\delta$, we obtain the following first-order condition, which is a rescaled version of (1):

$$\underbrace{\frac{w_\theta(0.5)}{1 - w_\theta(0.5)}}_{:=r_1} \frac{u'(x^-)}{u'(x^+)} = k - 1. \tag{6}$$

For Prelec's (1998) single parameter function, we have that the ratio $r_1(\theta) = \frac{w_\theta(0.5)}{1-w_\theta(0.5)}$ is increasing in $\theta$, as we graphically show in Appendix B. Consequently, in order to solve the first-order condition, the ratio of marginal utilities needs to increase as $\theta$ decreases, which requires $\delta$ to increase. Thus, a larger curvature parameter $\theta$ induces higher investment amounts.

In case of the symmetric multiplicative background risk, rank-dependent utility is given by

- $\delta \in [0, \frac{8}{23})$:

$$V(\widetilde{x}) = [w_\theta(0.25)(y^-)^{1-\gamma} + (w_\theta(0.75) - w_\theta(0.5))(y^+)^{1-\gamma}]u(x^-) \\ + [(w_\theta(0.5) - w_\theta(0.25))(y^-)^{1-\gamma} + (1 - w_\theta(0.75))(y^+)^{1-\gamma}]u(x^+).$$

- $\delta \in [\frac{8}{23}, 1]$:

$$V(\widetilde{x}) = [w_\theta(0.25)(y^-)^{1-\gamma} + (w_\theta(0.5) - w_\theta(0.25))(y^+)^{1-\gamma}]u(x^-) \\ + [(w_\theta(0.75) - w_\theta(0.5))(y^-)^{1-\gamma} + (1 - w_\theta(0.75))(y^+)^{1-\gamma}]u(x^+).$$

Note that at $\delta = \frac{8}{23}$, we have $x^+y^- = x^-y^+$, i.e. the two outcomes change their rank order. Thus, we need to exchange the decision weight ratio $r_1$ in (6) by $r_2$ and $r_3$ depending on the optimal $\delta$ and compare these ratios:

$$r_2(\theta) := \frac{w_\theta(0.25)(y^-)^{1-\gamma} + (w_\theta(0.75) - w_\theta(0.5))(y^+)^{1-\gamma}}{(w_\theta(0.5) - w_\theta(0.25))(y^-)^{1-\gamma} + (1 - w_\theta(0.75))(y^+)^{1-\gamma}} \quad \text{for } \delta \in [0, \frac{8}{23})$$

and

$$r_3(\theta) := \frac{w_\theta(0.25)(y^-)^{1-\gamma} + (w_\theta(0.5) - w_\theta(0.25))(y^+)^{1-\gamma}}{(w_\theta(0.75) - w_\theta(0.5))(y^-)^{1-\gamma} + (1 - w_\theta(0.75))(y^+)^{1-\gamma}} \quad \text{for } \delta \in [\frac{8}{23}, 1]$$

with the respective ratio without multiplicative background risk $r_1(\theta)$. A ratio higher than $r_1(\theta)$ indicates a lower optimal investment amount $\delta$ in the presence of multiplicative background risk compared to the control (as the ratio of marginal utilities needs to decrease). Similarly, if the ratio is lower than $r_1(\theta)$, optimal investment needs to be higher. We discuss details of these computations in Appendix B.

Similarly, in case of the skewed multiplicative background risk, rank-dependent utility is given by

- $\delta \in [0, \frac{2}{3})$:

$$V(\widetilde{x}) = [w_\theta(0.1)(y^-)^{1-\gamma} + (w_\theta(0.6) - w_\theta(0.2))(y^+)^{1-\gamma}]u(x^-) \\ + [(w_\theta(0.2) - w_\theta(0.1))(y^-)^{1-\gamma} + (1 - w_\theta(0.6))(y^+)^{1-\gamma}]u(x^+).$$

- $\delta \in [\frac{2}{3}, 1]$:

$$V(\widetilde{x}) = [w_\theta(0.1)(y^-)^{1-\gamma} + (w_\theta(0.5) - w_\theta(0.1))(y^+)^{1-\gamma}]u(x^-) \\ + [(w_\theta(0.6) - w_\theta(0.5))(y^-)^{1-\gamma} + (1 - w_\theta(0.6))(y^+)^{1-\gamma}]u(x^+).$$

Note that at $\delta = \frac{2}{3}$, we have $x^+y^- = x^-y^+$, i.e. the two outcomes change their rank order. Thus, we need to compare the decision weight ratios

$$r_4(\theta) := \frac{w_\theta(0.1)(y^-)^{1-\gamma} + (w_\theta(0.6) - w_\theta(0.2))(y^+)^{1-\gamma}}{(w_\theta(0.2) - w_\theta(0.1))(y^-)^{1-\gamma} + (1 - w_\theta(0.6))(y^+)^{1-\gamma}} \quad \text{for } \delta \in [0, \frac{2}{3})$$

and

$$r_5(\theta) := \frac{w_\theta(0.1)(y^-)^{1-\gamma} + (w_\theta(0.5) - w_\theta(0.1))(y^+)^{1-\gamma}}{(w_\theta(0.6) - w_\theta(0.5))(y^-)^{1-\gamma} + (1 - w_\theta(0.6))(y^+)^{1-\gamma}} \quad \text{for } \delta \in [\frac{2}{3}, 1]$$

with the respective ratio without multiplicative background risk $r_1(\theta)$. Again, we compute optimal investment amounts based on these ratios and show details of these computations in Appendix B.

Figure 2 displays optimal investment amounts without background risk as well as the symmetric and the skewed background risk depending on $\theta$. Individuals invest consistently more in the risky asset with skewed background risk compared to the situation without background risk. Accordingly, RDU implies a non-MRV choice for the skewed background risk independent of the values of the probability weighting function. In the case of the symmetric background risk, we observe MRV decision for $\theta$ close to 1. A common parametrization for $\theta$ in Prelec's (1998) function is $\theta = 0.65$ which implies a non-MRV decision for the symmetric background risk. For smaller values of $\theta$, however, the individual makes a MRV choice.

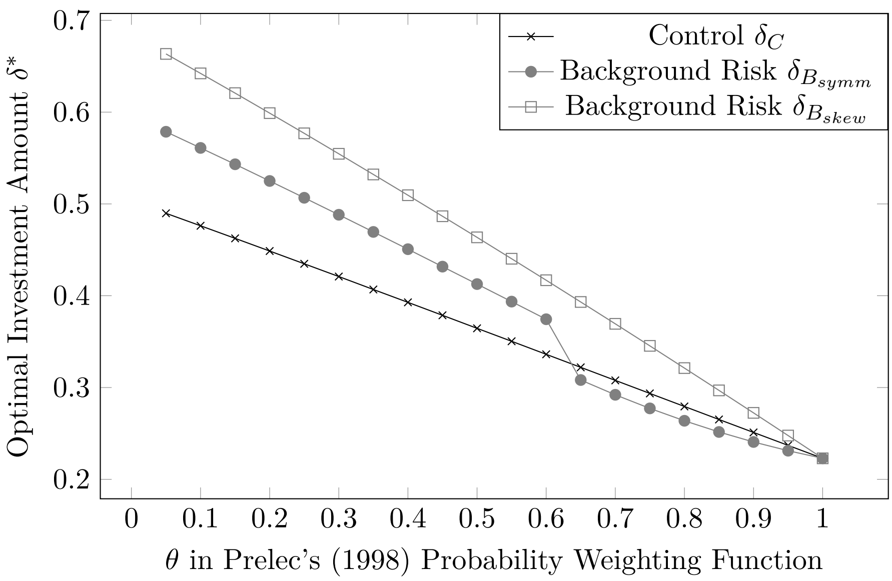


**Fig. 2:** Optimal investment amounts as functions of $\theta$: Comparison of control and symmetric background risk treatments

## 3 Experimental Design

In our incentivized experiment, we present our subjects with two scenarios of a simple portfolio choice problem where they decide how much to allocate to a risky asset. The final pay-off is subject to background risk in one scenario (choice $B$) while the other scenario (choice C) is without background risk. We classify all choices as multiplicative risk vulnerable if the subject invest equal or less amount with the background risk present. A choice is strictly multiplicative risk vulnerable if subjects invest strictly less with the present background risk. The setup is similar to the experiment conducted by Beaud and Willinger (2015) to test for (additive) risk vulnerability who also use the investment game initially proposed by Gneezy and Potters (1997).

We endow subjects with $x_0$ = EUR 8.00 and, as mentioned, all subjects make two investment choices, one with and one without a multiplicative background risk. The return on the investment $k$ equals 2.5 in the good state of the world in both choices. In the bad state of the world, individuals lose their investment. The expected return on each invested Cent/Euro is therefore 1.25.

In the task with a present background risk, we randomly assign subjects to a symmetric or a skewed background risk. In the symmetric case, the background risk equals $\widetilde{y} = [y^+, 0.5; y^-]$ with $y^+ = 1.4$ and $y^- = 0.6$, while it equals $\widetilde{y} = [y^+, 0.8; y^-]$ with $y^+ = 1.2$ and $y^- = 0.2$ in the skewed case. Both background risks are zero mean and they have identical variance.

Figure 3 shows the asset allocation task with a skewed multiplicative background risk where a random investment amount of EUR 4.20 was pre-selected. We utilize several measures to make the presentation of the investment task and the multiplicative background risk palpable. We present our investment choices in compound form (see Fig. 3) as this is preferable for risky lotteries as discussed by Harrison et al. (2015) and Deck and Schlesinger (2018). We display the background risk in absolute terms and indicate percentage changes. All probabilities are denoted as fractions out of 10 such as $\frac{5}{10}$. We visually support the notion of probabilities: we display the 50-50 probability of the investment risk by two boxes of identical size. We utilize pie charts to present the background risk probabilities. Subjects use sliders to determine the investment amount. Movement of the slider leads to automatical adjustment of displayed outcomes in all possible states of the world. We randomize for each subject whether the positive or negative outcome is presented on the left or right side.

Figure 4 illustrates the experimental timeline as displayed to subjects before their actual decisions. Individuals first solve a real effort task to alleviate the house money effect as discussed by (Thaler and Johnson, 1990) before subjects make the

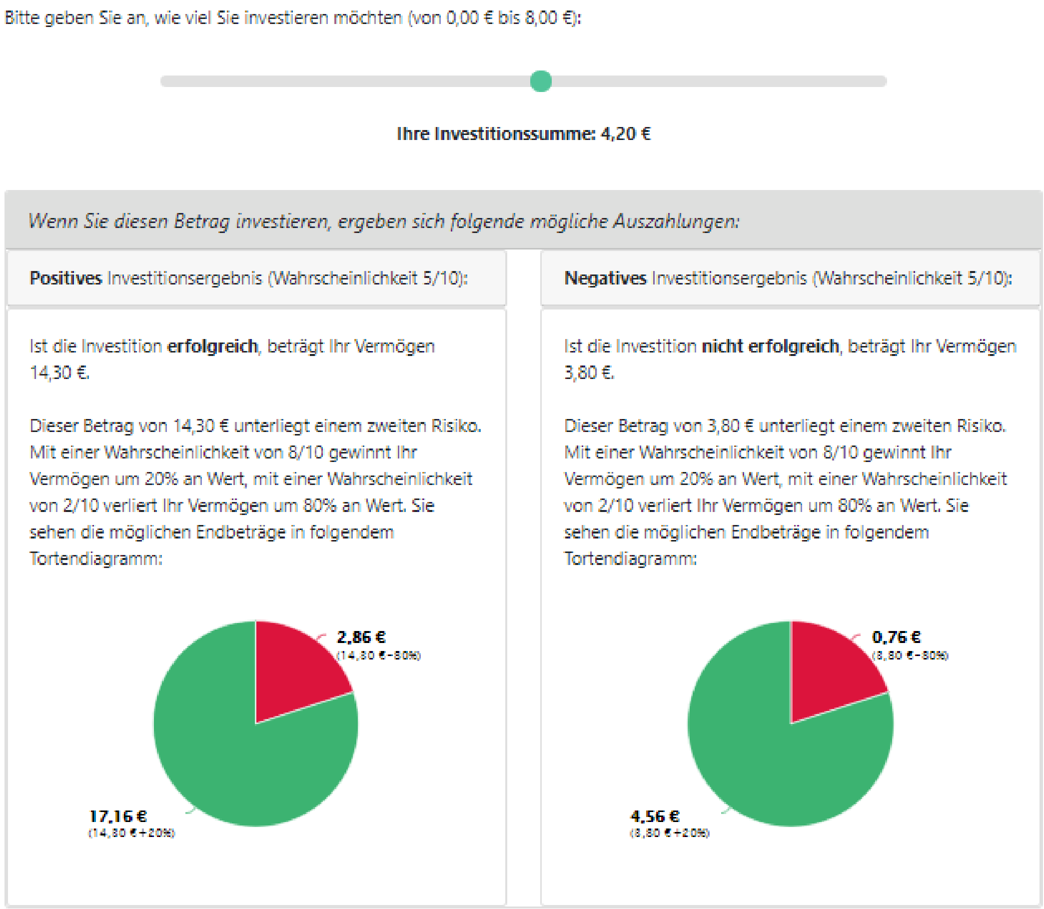


**Fig. 3:** Screenshot of the Background Risk Treatment

*Notes: This figure shows how the investment choice B is presented in compound form. In this example,* $\delta s$ *=* *EUR* 4.20 *and* $x_0$ *=* *EUR* 8.00*. Screenshot from the experiment in German. English translation in the Appendix.*

two asset allocation tasks. We randomize the order of these two asset allocation tasks for each individual to rule out potential order effects (Harrison et al., 2005). In part IV, we collect sociodemographic variables in a questionnaire. Finally, all randomizations play out and final pay-offs are displayed to the subjects.

The experiment was conducted online facilitated by the WiSo-Experimentallabor of the Universität Hamburg in August 2021. During the Covid 19 health crises, the WiSo-Experimentallabor developed an online labratory where participants are supervised at their home-computers while playing the experiment. We use oTree (Chen et al., 2016) for programming and hroot (Bock et al., 2014) for randomized recruiting within the subject pool of the WiSo-lab, which mostly consists of students. In total, 334 participants took part in six experimental sessions. All subjects only participated in one session.

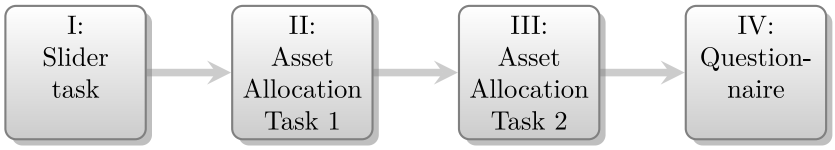


**Fig. 4:** Structure of the experiment

We informed participants at the beginning of the experiment that one out of the two investment choices will be randomly picked and played out.[3] The experiment lasted about 25 minutes on average and subjects' average payment was EUR 8.52 (about USD 9.97 at that time), with values ranging from EUR 0 to EUR 28.

# 4 Experimental Results

## 4.1 Summary Statistics

Table 3 shows summary statistics of individual characteristics of the 301 experiment's subjects that we include in our analysis.[4] On average, individuals invest 4.18 EUR without background risk (investment_c) and 4.41 EUR with background risk (investment_b). The higher average investment amount with background risk points towards non-MRV choices. Average age is 25.75 years, as the majority of subjects are students. We observe 65% female participants, which can be attributed to the fact that the main campus, where the lab is located, mostly hosts humanities

[3] See Cubitt et al. (1998) and Azrieli et al. (2018) for discussion on the validity of the random payment technique.

[4] We exclude four subjects who spent substantially less time on the decision screens than everyone else. We additionally exclude 29 participants who do not touch all sliders in the slider task at least once. In Appendix C, we report experimental results including these 29 subjects. Our conclusions do not substantially differ depending on whether we include these subjects or not.

and social sciences, while math and sciences have separate campus locations. One individual identifies as non-binary. The majority of the sample has already taken part in additional experiments.

**Table 3:** Summary statistics

| | Mean | Minimum | 1st Quartile | Median | 3rd Quartile | Maximum | SD |
|---|---|---|---|---|---|---|---|
| investment_c | 4.18 | 0.00 | 3.00 | 4.00 | 5.20 | 8.00 | (2.23) |
| investment_b | 4.41 | 0.00 | 3.00 | 4.00 | 6.00 | 8.00 | (2.27) |
| Age | 25.75 | 19.00 | 23.00 | 25.00 | 28.00 | 58.00 | (4.99) |
| Female | 0.65 | | | | 1.00 | | |
| GRQ | 4.85 | 1.00 | 3.00 | 5.00 | 6.00 | 10.00 | (2.07) |
| First Time | 0.06 | | | | | | |
| Observations | 301 | | | | | | |

Table 4 provides summary statistics of the subjects' investment choices split up by whether they are exposed to the skewed (column 1) or the symmetric background risk (column 2). Column 3 shows the difference in means between the different background risks. We compute two-sided Wilcoxon rank sum tests to asses whether the observed differences are statistically significant. We do not find significant differences for investments without background risk (investment_c), age, gender, whether this is the subject's first time in the lab or for majors. We find marginally significant differences between the investment amount with background risk (investment_b) depending on the kind of background risk the subjects are exposed to. We find that subjects invest EUR 0.47 more into the risky asset on average when exposed to the skewed background risk. The average investment with symmetric background risk equals EUR 4.16, which is almost identical to the mean investment without background risk over all subjects (EUR 4.18) which is displayed in Table 3. In addition, we observe a marginally statistically significant difference in the GRQ between subjects exposed to the skewed and symmetric background risk. This is of potential concern as differences in risk preferences may drive the differences in investments amounts under the skewed and the symmetric background risk. We do not observe any differences in investment amounts without background risk without controls which alleviates the above mentioned concerns.

As pointed out in the previous section, we randomized the order of the two investment choices presented to our subjects: approximately half of our subjects first decide on their investment with background risk and half without background risk.

**Table 4:** Summary by Background Risk

| | Skewed BR | Symmetric BR | Diff |
|---|---|---|---|
| investment_c | 4.183 | 4.167 | 0.016 |
| | (2.180) | (2.276) | |
| investment_b | 4.643 | 4.177 | 0.466* |
| | (2.136) | (2.388) | |
| Age | 25.98 | 25.53 | 0.454 |
| | (5.545) | (4.394) | |
| Female | 0.631 | 0.678 | -0.047 |
| | (0.484) | (0.483) | |
| GRQ | 5.040 | 4.671 | 0.369* |
| | (2.050) | (2.071) | |
| First Time | 0.054 | 0.060 | -0.006 |
| | (0.226) | (0.237) | |
| Law Major | 0.121 | 0.099 | 0.022 |
| | (0.327) | (0.299) | |
| Business Major | 0.134 | 0.086 | 0.049 |
| | (0.342) | (0.281) | |
| Education Major | 0.121 | 0.112 | 0.009 |
| | (0.327) | (0.316) | |
| Humanities Major | 0.121 | 0.145 | -0.024 |
| | (0.327) | (0.353) | |
| Medicine Major | 0.027 | 0.007 | 0.020 |
| | (0.162) | (0.081) | |
| Sciences Major | 0.148 | 0.217 | -0.069 |
| | (0.356) | (0.414) | |
| Social Sciences Major | 0.275 | -0.021 | 0.286 |
| | (0.448) | (0.458) | |
| Other Major | 0.040 | 0.033 | 0.007 |
| | (0.197) | (0.179) | |
| Major not specified | 0.013 | 0.007 | 0.007 |
| | (0.115) | (0.081) | |
| Observations | 301 | | |

*Notes:* mean coefficients; sd in parentheses;
Diff: two-sided Wilcoxon rank-sum test, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

### 4.2 Impact of Type of Background Risk

#### 4.2.1 Skewed Background Risk

As the summary statistics already indicate, we observe different behavior depending on whether the individual faces the symmetric or the skewed background risk. For this reason, we provide our main analysis separately for both types of background risks. We start with the skewed background risk.

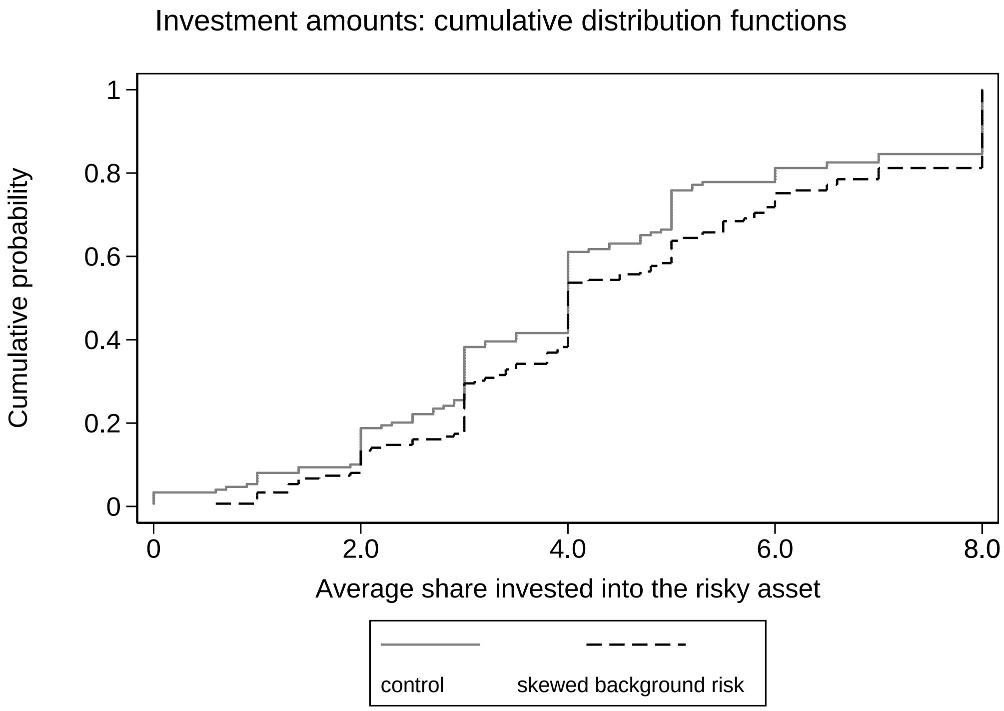


**Fig. 5:** Cumulative distribution functions of investment amounts, skewed background risk treatment
*Notes:* This figure shows the cumulative distribution functions of the investment amounts for the control and the skewed background risk investment games.

Figure 5 shows the cumulative distribution functions (cdfs) for the investment amounts in the control treatment and the skewed background risk treatment. We observe that the investment amount in the skewed background risk treatment first-order stochastically dominates the investment amount in the control treatment, indicating that these investment amounts are different and subjedcts invest less without background risk. The difference in mean investment amounts between the skewed background risk treatment and the control treatment amounts to around 0.46 EUR (see Table 4), indicating individuals to be less risk averse in the presence of the skewed background risk. To further analyse this, we run a Wilcoxon signed-rank test against the null hypothesis that investment amounts are the same. The test rejects the null hypothesis ($p = 0.010$). This implies that investment amounts in the skewed background risk treatment are significantly larger than investment amounts in the control treatment.

In Table 5, we report classification of individuals' choices and the respective investment amounts. 44% of choices in this treatment can be classified as non-risk vulnerable, i.e. the individual invests strictly more in the skewed background risk treatment compared to the control decision. On the other side, approximately 29% of choices are in accordance with multiplicative risk vulnerability. Approximately 26% of the subjects make identical choices with and without background risk. These figures are based on the subsample of subjects that we can classify appropriately. To do so, we have to drop 22 subjects investing the maximum or minimum in both choices. These subjects cannot be reliably classified as the following example illustrates: a subject who invests EUR 8 in both treatments may be MRV indifferent, but could also be MRV or non-MRV as they potentially would have borrowed additional money to invest more than EUR 8 with or without the background risk. [5]

**Table 5:** Investment choices and classification - skewed background risk treatment, reduced sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **29.13** | 26.77 | **44.09** | **100** |
| $\delta_C$ (mean) | **4.2235** | 3.5297 | **3.0911** | **3.5220** |
| $\delta_B$ (mean) | **3.1147** | 3.5297 | **4.9875** | **4.0614** |
| No. of Observations | **37** | 34 | **56** | **127** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table excludes subjects who invest the same limiting amount in both choices.

We also run a binomial test on the classification in (non-) risk vulnerable choices. This test rejects the null hypothesis of random behavior (i.e. the probability of making a risk vulnerable choice, conditional on making a choice, being 0.5) ($p = 0.026$). This again provides support of a significant effect of the skewed background risk on classification. Accordingly, we observe more non-MRV choices than MRV choices. In addition, investment amounts are significantly larger on aggregate in the presence of the skewed background risk compared to the control investment decision. Thus, we find support of individuals **not** behaving in accordance with multiplicative risk vulnerability in the presence of the skewed background risk.

[5] In Table D.1 in the Appendix, we include these 23 individuals and consider them to be indifferent.

#### 4.2.2 Symmetric Background Risk

Figure 6 plots the cumulative distribution functions of the investment amounts in the symmetric background risk treatment and the control treatment. Unlike in the case of the skewed background risk, the curves are much closer together in this case. The difference in mean investment amounts is -0.01 EUR (see Table 4). Consequently, the Wilcoxon signed-rank test fails to reject the null hypothesis of equal investment amount distributions.

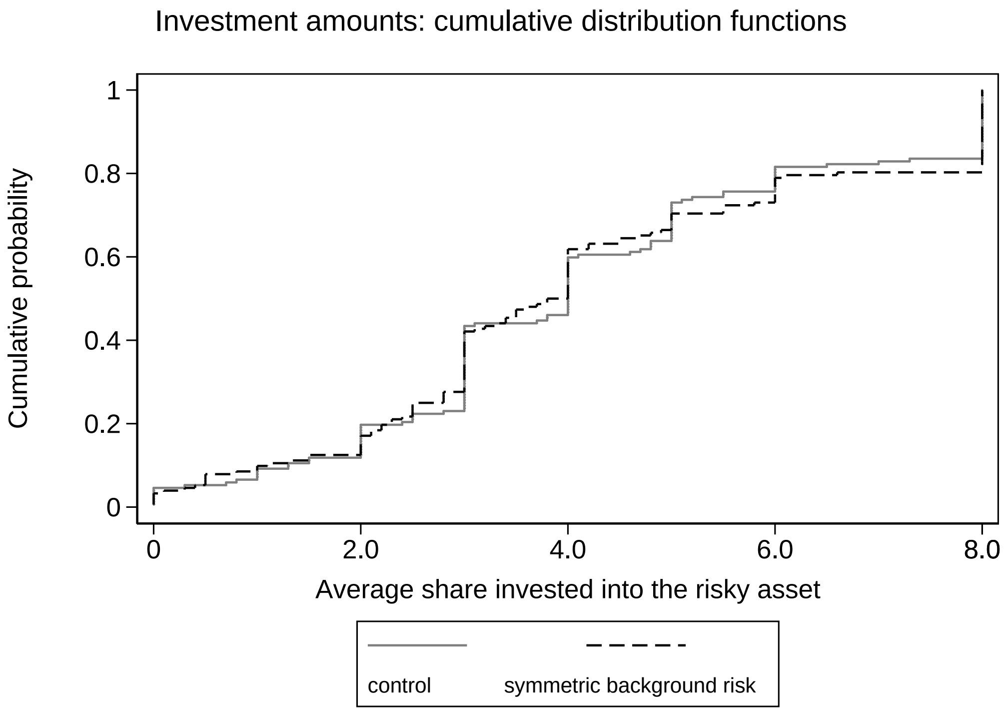


**Fig. 6:** Cumulative distribution functions of investment amounts, symmetric background risk treatment
*Notes:* This figure shows the cumulative distribution functions of the investment amounts for the control and the symmetric background risk investment games.

Again, we exclude those individuals who cannot be classified because they invest the same limiting amount (27 individuals). We present the classification for this reduced sample in Table 6. In this sample, 40% of choices are risk vulnerable, while 35% are not in accordance with multiplicative risk vulnerability. [6] A binomial test fails to reject the null hypothesis of random (or indifferent) behavior at any usual significance level ($p = 0.606$). Overall, our results indicate that, on aggregate, investment with the symmetric background risk is not different than investment without multiplicative background risk.

[6] In Table D.2 in the Appendix, we include the 27 indifferent subjects.

**Table 6:** Investment choices and classification - symmetric background risk treatment, reduced sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **40.00** | 24.80 | **35.20** | **100** |
| $\delta_C$ (mean) | **4.2560** | 3.7516 | **2.7341** | **3.5952** |
| $\delta_B$ (mean) | **2.9320** | 3.7516 | **4.2727** | **3.6072** |
| No. of Observations | **50** | 31 | **44** | **125** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table excludes subjects who invest the same limiting amount in both choices.

### 4.2.3 Comparison Skewed and Symmetric Background Risk

In the previous two subsections, we find support that skewed background risk significantly increases risk taking in the investment task, while symmetric background risk does not change risk taking. In the following, we check whether these differences are also statistically significant, i.e. whether behavior significantly changes across background risk treatments. The mean difference in investment amounts between $B$ and $C$ is around 0.45 EUR in the skewed background risk treatment, while it is 0.01 EUR in the symmetric background risk treatment. This difference is significant ($p = 0.018$, two-sample Wilcoxon rank-sum test). We also run a proportion test on the proportion of multiplicative risk vulnerable choices (conditional on making a choice) across the two treatments. We observe 38% of choices are in accordance with multiplicative risk vulnerability in the skewed background risk treatment, while the proportion is 53% in the symmetric background risk treatment (excluding indifferent subjects). The proportion test indicates that these proportions are significantly different ($p = 0.036$). These tests provide evidence that it is the shape of the background risk that determines risk taking but not the mere presence of a multiplicative background risk.

Table 7 presents regression results on the likelihood to make a MRV choice. We only include subject which can be strictly classified, i.e. who invest different amounts with and without background risk. We include sampled socio-demographics to assess whether we find additional factors that drive MRV choices and to account for potential confounders which may arise due to differences in the two treatment groups (Column 2). Without and with additional controls, we observe a significant positive effect of the symmetric background risk on the likelihood to make a choice in accordance with multiplicative risk vulnerability. Estimates are significant on the 5%-level. We do not find a significant impact of any other socio-demographic variables on the likelihood to make a MRV choice including the GRQ, gender, age, major and whether subjects played in an experiment for the first time.

**Table 7:** Probability to Make a MRV Choice

| | (1) | (2) |
|---|---|---|
| | Probit: MRV | Probit: MRV |
| Symmetric Background Risk | 0.391** (0.187) | 0.471** (0.198) |
| GRQ | | -0.046 (0.056) |
| Female | | 0.252 (0.237) |
| Non-binary | | 0 (.) |
| Age | | -0.007 (0.022) |
| First Time | | 0.469 (0.402) |
| Business Major | | 0.643 (0.408) |
| Education Major | | 0.235 (0.394) |
| Humanities Major | | -0.123 (0.429) |
| Medicine Major | | 0.183 (0.688) |
| Sciences Major | | -0.063 (0.383) |
| Social Sciences major | | -0.243 (0.358) |
| Other Major | | -0.045 (0.693) |
| Major not specified | | 0 (.) |
| Constant | -0.311** (0.135) | -0.197 (0.765) |
| $N$ | 184 | 182 |
| Pseudo R-Squared | 0.0174 | 0.0693 |

Dependent Variable: Choice in accordance with strict MRV.

Robust standard errors in parentheses: $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

Table 8 shows an OLS regression on difference in investment amounts between control and background risk. We also observe a significant positive impact of the symmetric background risk on the difference in investment amounts between control and background risk treatment. Without additional controls, the coeffiecient estimate equals EUR 0.45. With additional controls, the coefficient estimate reduces to EUR 0.40. Both estimates are statistically significant at the 5% level. These results support our previous findings: the type of background risk has a significant impact on changes in risk taking. We further observe that none of the sociodemographical characteristics are significantly associated with differences in investment amounts other than being non-binary compared to being male. As we only have one non-binary subject, we refrain from discussing the economic impact of being non-binary on the difference in investments amounts.

**Table 8:** Difference in Investments with and without Background Risk

| | (1)<br>OLS: diff | (2)<br>OLS: diff |
|---|---|---|
| Symmetric Background Risk | 0.450** (0.190) | 0.403** (0.191) |
| GRQ | | -0.045 (0.041) |
| Female | | 0.150 (0.216) |
| Non-binary | | 0.972*** (0.278) |
| Age | | -0.019 (0.022) |
| First Time | | 0.362 (0.338) |
| Business major | | 0.150 (0.380) |
| Education Major | | 0.227 (0.371) |
| Medicine Major | | -0.941 (1.491) |
| Sciences Major | | -0.130 (0.354) |
| Social Sciences Major | | 0.007 (0.318) |
| Other Major | | -0.846 (0.845) |
| Major not specified | | 0.144 (0.406) |
| Constant | -0.460*** (0.141) | 0.166 (0.642) |
| *N* | 301 | 301 |
| R-Squared | 0.0185 | 0.0523 |

Difference in investment amounts with and without background risk treatment.

Robust standard errors in parentheses: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

# 5 Conclusion

Even though multiplicative background risk appears in many situations such as risky inflation, tax rates or exchange rates, we know little whether individuals have MRV preferences and consequently make MRV choices. In the example of a random exchange rate, multiplicative risk vulnerability would imply that an individual reduces investment in a risky asset as final wealth does not only depend on the realization of the investment but also on the realization of the exchange rate.

In this paper, we therefore posit the question whether we actually observe multiplicative risk vulnerable choices in individuals. We revisit the standard portfolio choice problem and discuss how a multiplicative background risk changes investment into the risky asset under EUT, CPT and RDU. EUT predicts no changes in risk taking under commonly assumed CRRA-preferences. CPT predicts mostly more risk taking with present multiplicative background risk, while RDU finds that a left-skewed background risk increases risk taking while a symmetric background risk has little impact on risk taking. Altogether, all approaches fail to make unambiguous predictions whether the presence of a multiplicative background risk decreases risk taking as it depends on parametrization. In order to understand behavior in the presence of multiplicative background risk better, we conduct a lab experiment where subjects decide on how much to allocate to a risky asset with and without a present background risk. We find that the addition of a skewed background risk leads to more risk taking while we do not find any significant changes in risk-taking behavior when adding a symmetric background risk. Neither gender, the general risk question or other sociodemographic factors are associated with the propensity to make a MRV choice.

Summing up, multiplicative risk vulnerable preferences imply that the endogenous and the exogenous risks are substitutes as long as the exogenous risk does not increase expected wealth. This is intuitively a strong assumption as the interaction of the volatility in wealth caused by the background risk with the risk taking in the endogenous risk can favor more risk taking. As noted by Franke et al. (2006), most of the commonly used utility functions in EUT do not necessarily satisfy conditions for MRV. Our paper shows that risk taking increases sizably when we increase the skewness of background risk. Rather than trying to find conditions on utility functions that predict MRV choices for all kinds of (un)fair multiplicative background risks, we point future research to the direction of investigating the impact of characteristics of the background risk on risk taking.

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# A Expected Utility Theory and Full Asset Integration

In this section, we study optimal investment amounts within Expected Utility Theory (EUT) and full asset integration. For this, we denote by $w_0$ the individual's real life assets. We assume that there exists a von Neumann-Morgenstern utility function $v$ with $v' > 0$ and $v'' < 0$ such that the decision maker's preference function over random wealth $\widetilde{x}(\delta)$ is given by

$$V(w_0 + \widetilde{x}(\delta)) = \mathbb{E}[v(w_0 + \widetilde{x}(\delta))].$$

We now define a second utility function $u(x) := v(w_0 + x)$. Again, we have $u' > 0$ and $u'' < 0$ as these inequalities hold for $v$. Thus, we can also write the preference functional in terms of $u$ rather than $v$ as

$$V(w_0 + \widetilde{x}(\delta)) = \mathbb{E}[u(\widetilde{x}(\delta))].$$

Thus, decisions with respect to the random component $\widetilde{x}(\delta)$ made according to either $v$ and $u$ are identical. For ease of notation, we will consider the utility function $u$. Following Franke et al. (2006), we define an additional utility function $U$ defined by

$$U(x) = \int_a^b u(xy)dG(y) = \mathbb{E}[u(x\widetilde{y})] = \mathbb{E}[v(w_0 + x\widetilde{y})].$$

Note that $U$ again is increasing and concave, as $u$ is. We can interpret the relationship between $u$ and $U$ such that a decision-maker with utility function $u$, who faces the additional multiplicative background risk $\widetilde{y}$, behaves in the same way as another decision-maker with utility function $U$ without any multiplicative background risk.

Now consider the experimental choices. In the control treatment, the random wealth is given by $\widetilde{x}(\delta) = x_0 + \delta(\widetilde{k} - 1)x_0$, where $\widetilde{k}$ denotes a random variable taking on values 0 and $k$ with equal probability. Denote by $x^-(\delta) := x_0 - \delta x_0$ and $x^+(\delta) := x_0 + \delta k x_0$ wealth when the investment failed or is successful, respectively. If an interior solution $\delta^* \in [0,1]$ to the optimization problem exists, then it follows easily that the optimal investment $\delta^*$ solves the following condition (Beaud and Willinger, 2015):

$$\frac{u'(x^-)}{u'(x^+)} = k - 1.$$

If $\frac{u'(x^-)}{u'(x^+)} > k - 1$ for $\delta = 0$, then $\delta^* = 0$. Similarly, if $\frac{u'(x^-)}{u'(x^+)} < k - 1$ for $\delta = 1$, then $\delta^* = 1$. To summarize, the optimal investment $\delta^*$ is given by (Beaud and Willinger, 2015):

$$\delta^* = 1 \qquad \text{if } \frac{u'(x^-(1))}{u'(x^+(1))} < k-1$$

$$\delta^* \in [0{,}1] \qquad \text{if } \frac{u'(x^-(\delta^*))}{u'(x^+(\delta^*))} = k-1$$

$$\delta^* = 0 \qquad \text{if } \frac{u'(x^-(0))}{u'(x^+(0))} > k-1$$

In the presence of the multiplicative background risk, decisions can be described by utility function $U$ rather than $u$. Thus, in the presence of multiplicative background risk, we end up with the same conditions with $u$ being substituted by $U$.

From Theorem 1 in Pratt (1964), we know that utility function $U$ is at least as risk averse than utility function $u$ if and only if

$$\frac{u'(a)}{u'(b)} \leq \frac{U'(a)}{U'(b)} \quad \text{for all } a \leq b. \tag{7}$$

Note that $x^- < x^+ \Leftrightarrow \delta > 0$, i.e. it holds for the ratios $\frac{u'(x^-)}{u'(x^+)} > 1 \Leftrightarrow \delta > 0$ as well as $\frac{U'(x^-)}{U'(x^+)} > 1 \Leftrightarrow \delta > 0$. Moreover, due to concavity of both $u$ and $U$, the ratios are increasing in $\delta$. Thus, if $U$ is at least as risk averse as $u$, we observe a multiplicative risk vulnerable choice, i.e. $\delta^*_B \leq \delta^*_C$. Equivalently, we can also formulate this in terms of the coefficients of absolute risk aversion, $r^u_A$ and $r^U_A$: we observe $\delta^*_B \leq \delta^*_C$ if

$$r^u_A(x) = -\frac{u''(x)}{u'(x)} \leq -\frac{U''(x)}{U'(x)} = r^U_A(x) \ \text{ for all } x > 0. \tag{8}$$

To summarize, we get the following result, which is similar to Proposition 1 in Beaud and Willinger (2015)

**Proposition 2.** *If $U$ is at least as risk averse as $u$ ($r^u_A \leq r^U_A$), the decision-maker makes a (partial) multiplicative risk vulnerable choice ($\delta^*_C \geq \delta^*_B$).*

Substituting back $v$ for $u$ into (8), the condition becomes

$$-\frac{v''(w_0 + x)}{v'(w_0 + x)} \leq -\frac{\mathbb{E}[v''(w_0 + x\widetilde{y})\widetilde{y}^2]}{\mathbb{E}[v'(w_0 + x\widetilde{y})\widetilde{y}]} \ \text{ for all } x > 0. \tag{9}$$

Thus, we can restate Proposition 2 in terms of the utility function $v$

**Proposition 3.** *If* $-\frac{v''(w_0+x)}{v'(w_0+x)} \leq -\frac{\mathbb{E}[v''(w_0+x\widetilde{y})\widetilde{y}^2]}{\mathbb{E}[v'(w_0+x\widetilde{y})\widetilde{y}]}$ *for all $x > 0$, then the decision-maker makes a (partial) multiplicative risk vulnerable choice ($\delta^*_C \geq \delta^*_B$).*

We now address the question under which conditions on the utility function $v$ (9) (respectively (8)) holds. In case of a multiplicative background risk that affects the total wealth of the individual, Franke et al. (2006) derive conditions such that the decision-maker behaves more cautiously in the presence of the multiplicative background risk. These conditions are found to be closely related to the coefficient of relative risk aversion $r_R^u(x) = -x\frac{u''(x)}{u'(x)}$. Their conditions can be easily applied to the utility function $u$ considered above. However, the individual's utility over final wealth is given by $v$ rather than $u$ and we point out that the coefficients of relative risk aversion of $u$ and $v$ are not identical (as opposed to the coefficient of absolute risk aversion, for instance). As we want to provide conditions on the utility function $u$ for (9) to hold, we need to adapt the results provided in Franke et al. (2006) to account for the fact that multiplicative background risk only partially affects final wealth.

First, note that for any $x > 0$[7] (9) is equivalent to

$$-x\frac{v''(w_0 + x)}{v'(w_0 + x)} \leq -x\frac{\mathbb{E}[v''(w_0 + x\widetilde{y})\widetilde{y}^2]}{\mathbb{E}[v'(w_0 + x\widetilde{y})\widetilde{y}]} \quad \text{for all } x > 0. \tag{10}$$

Our first result provides the necessary and sufficient condition on the utility function $v$ such that (9) holds. The result makes use of the coefficient of *partial relative* risk aversion, which is defined as $r_P(w_0,x) = -x\frac{v''(w_0+x)}{v'(w_0+x)}$. We denote by $r'_P(w_0,x)$ the first derivative of $r_P(w_0,x)$ with respect to $x$.

**Proposition 4.** *Assume a decision-maker with initial endowment $w_0$ that is not subject to multiplicative background risk. Preferences exhibit (partial) multiplicative risk vulnerability for all $x > 0$ and random variables $\widetilde{y}$ with support in $[a,b]$ and $\mathbb{E}[\widetilde{y}] = 1$ if and only if for all $x > 0$ and $y \in [a,b]$*

$$v'(w_0 + xy)y[r_P(w_0,xy) - r_P(w_0,x)] - (y-1)v'(w_0 + x)xr'_P(w_0,x) \geq 0.$$

This result can be proven using the diffidence theorem (Gollier and Kimball, 2018) in a way very similar to the proof of the main theorem in Franke et al. (2006) and is thus omitted here.

Hence, unlike the case in which multiplicative background risk affects total wealth and *relative* risk aversion determines the individual's behavior, in case of partial multiplicative background risk, the coefficient of *partial relative* risk aversion plays the important role. Partial relative risk aversion was originally proposed independently by Menezes and Hanson (1970) and Zeckhauser and Keeler (1970) (who call it *size-of-risk* aversion). Note that if $w_0 = 0$, partial multiplicative risk vulnerability collapses into the usual multiplicative risk vulnerability of Franke et al. (2006).

Unlike the coefficients of absolute and relative risk aversion, the coefficient of

[7] Note that in our experimental setup, $x_s(\delta) > 0$ and $x_f(\delta) > 0$ for all possible values of $\delta \in [0,1]$.

partial relative risk aversion plays a less prominent role in the literature on risk-taking. To provide some intuition of why we rely on partial relative risk aversion rather than relative risk aversion, we consider the relationship of these coefficients with the risk premium for the risk $\widetilde{x}(\delta)$ at some fixed value of $\delta \in [0,1]$. First consider the case in which multiplicative background risk $\widetilde{y}$ acts on total wealth: random total final wealth is then given by $(w_0 + \widetilde{x}(\delta))\widetilde{y} = w_0\widetilde{y} + \widetilde{x}(\delta)\widetilde{y}$. Then we have for any fixed realization $y$ of $\widetilde{y}$ that the risk premium $\pi(w_0 y,\widetilde{x}(\delta)y)$ for $\widetilde{x}(\delta)$ solves

$$v(w_0 y + \mathbb{E}[\widetilde{x}(\delta)y] - \pi(w_0 y,\widetilde{x}(\delta)y)) = \mathbb{E}[v(w_0 y + \widetilde{x}(\delta)y)].$$

Now the coefficient of relative risk aversion, $r_R^v$ provides information on proportionate changes in the risk premium, i.e. how $\frac{\pi(w_0 y,\widetilde{x}(\delta)y)}{y}$ changes as $y$ changes:

$$\frac{\partial}{\partial y}\frac{\pi(w_0 y,\widetilde{x}(\delta)y)}{y} > (= , <)\ 0$$

if $r_R^v(x)$ is increasing (constant, decreasing) (Menezes and Hanson, 1970). As the multiplicative background risk ultimately results in exactly these kinds of changes, depending on its realization, it is not surprising that the shape of relative risk aversion plays an important role in characterizing multiplicative risk vulnerable behavior.

Now consider the case in which the decision-maker's initial endowment $w_0$ is not affected by multiplicative background risk. Then random total final wealth is given by $w_0 + \widetilde{x}(\delta)\widetilde{y}$. Then, we have for any fixed realization $y$ of $\widetilde{y}$ that the risk premium $\pi(w_0,\widetilde{x}(\delta)y)$ for $\widetilde{x}(\delta)$ solves

$$v(w_0 + \mathbb{E}[\widetilde{x}(\delta)y] - \pi(w_0,\widetilde{x}(\delta)y)) = \mathbb{E}[v(w_0 + \widetilde{x}(\delta)y)].$$

Now the coefficient of partial relative risk aversion, $r_P^v$ similarly informs us about proportionate changes in this risk premium, i.e. how $\frac{\pi(w_0,\widetilde{x}(\delta)y)}{y}$ changes as $y$ changes:

$$\frac{\partial}{\partial y}\frac{\pi(w_0,\widetilde{x}(\delta)y)}{y} > (= , <)\ 0$$

if $r_P^v(w_0,x)$ is increasing (constant, decreasing) (Menezes and Hanson, 1970). Thus, unlike the coefficient of relative risk aversion, which considers the case of proportionate increases in both the wealth and the risk, the coefficient of partial relative risk aversion considers proportionate changes in risk, leaving wealth constant. This is closely related to the situation in which the decision-maker faces partial multiplicative background risk: any realization of the background risk results in a proportionate change in risk, leaving wealth constant. Thus, it is not surprising that in case of partial multiplicative background risk, the coefficient of partial relative risk aversion drives the result.

The condition given in (4) is difficult to deal with. However, we get the following two corollaries, which are adapted versions of Corollaries 1 and 2 in Franke et al. (2006) and follow easily from Proposition 4.

**Corollary 3.** *Suppose that $r_P^v(w_0,x)$ is convex and one of the following conditions holds for all $(x,y) \in Supp(F) \times Supp(G)$:*

1. $r_P^v(w_0,xy) > 1$ *and* $r_P^v$ *decreasing,*

2. $r_P^v(w_0,xy) < 1$ *and* $r_P^v$ *increasing.*

*Then (10) holds, i.e. the decision-maker is partial multiplicative risk vulnerable.*

**Corollary 4.** *Suppose that $r_P^v(w_0,x)$ is concave and one of the following conditions holds for all $(x,y) \in Supp(F) \times Supp(G)$:*

1. $r_P^v(w_0,xy) > 1$ *and* $r_P^v$ *increasing,*

2. $r_P^v(w_0,xy) < 1$ *and* $r_P^v$ *decreasing.*

*Then (10) holds, i.e. the decision-maker is partial multiplicative risk vulnerable.*

The coefficient of partial relative risk aversion $r_P^v(w_0,x)$ relates to the coefficients of absolute risk aversion, $r_A^v(x)$, and relative risk aversion, $r_R^v(x)$. Thus, some properties of these two coefficients carry over to the coefficient of partial relative risk aversion. With respect to absolute risk aversion, we have

$$r_P^v(w_0,x) = x r_A^v(w_0 + x).$$

Taking the first derivative with respect to $w_0$, we thus obtain

$$\frac{\partial}{\partial w_0} r_P^v(w_0,x) = x \frac{\partial}{\partial w_0} r_A^v(w_0 + x),$$

which indicates that decreasing absolute risk aversion results in decreasing partial risk aversion *with respect to initial wealth* (Bar-Shira et al., 1997). Moreover, in terms of the coefficient of relative risk aversion, the coefficient of partial relative risk aversion can be written as

$$r_P^v(w_0,x) = \frac{x}{w_0 + x} r_R^v(w_0 + x). \tag{11}$$

Taking the first derivative with respect to $x$ yields (Bar-Shira et al., 1997):

$$\frac{\partial}{\partial x} r_P^v(w_0,x) = \frac{w_0}{(w_0+x)^2} r_R^v(w_0+x) + \frac{x}{w_0+x} \frac{\partial}{\partial x} r_R^v(w_0+x).$$

Consequently, increasing relative risk aversion implies increasing partial relative risk aversion (constant relative risk aversion implies increasing partial risk aversion for $w_0 > 0$). Moreover, given that $\frac{w_0}{w_0+x} < 1$, it follows from (11) that if relative risk aversion is smaller than unity, then this carries over to partial relative risk aversion. Note that in these relations, the reverse implications are generally not true. (11) also shows that relative and partial relative risk aversion are the more similar the smaller $w_0$ is.

Some of the conditions in the previous corollaries can thus be inferred from the coefficient of relative risk aversion, which has widely been studied in both the theoretical and empirical literature. With respect to theoretical studies, albeit not as prominent as the coefficient of relative risk aversion, the coefficient of partial risk aversion plays an important role in determining decisions under risk (examples can be found in a magnitude of studies, e.g. Eeckhoudt et al. (1995), Dionne and Gollier (1992), Steinorth (2011) and Tsetlin and Winkler (2005)). Some empirical studies that assess partial relative risk aversion directly find support for increasing partial relative risk aversion (e.g. Binswanger (1981) and Wik et al. (2004)).

# B RDU: Comparison of weighting ratios

In this section, we first compare the weighting ratios $r_1, r_2, r_3$ for the symmetric background risk case. Figure B.1 shows the plot as functions of the single parameter $\theta$ in the probability weighting function. Note that at around $\theta = 0.606$, the optimal $\delta^*$ changes from being on $[0,\frac{8}{23})$ to being on $[\frac{8}{23},1]$. Thus, this $\theta$ serves as a cutoff point. Above this value, we need to relate $r_2(\theta)$ and $r_1(\theta)$. As can be seen from Figure B.1, for these values of $\theta$, $r_2(\theta) > r_1(\theta)$, which results in the optimal investment amount being lower than without background risk. This is due to more weight being placed on the bad investment outcome relative to the good investment outcome. Below $\theta = 0.606$, we need to compare $r_3(\theta)$ and $r_1(\theta)$. As shown clearly in Figure B.1, we have $r_3(\theta) < r_1(\theta)$, which indicates the optimal $\delta^*$ with multiplicative background risk to be larger than in the control treatment. This is due to relative overweighing of the good investment outcome relative to the bad investment outcome. These findings are summarized in Figure 2.

Figure B.2 shows the plot as functions of the single parameter $\theta$ in the probability weighting function in case of the skewed background risk. We plot these ratios together with the ratio $r_1(\theta)$ in Figure B.2. Both ratios $r_4(\theta)$ and $r_5(\theta)$ are clearly

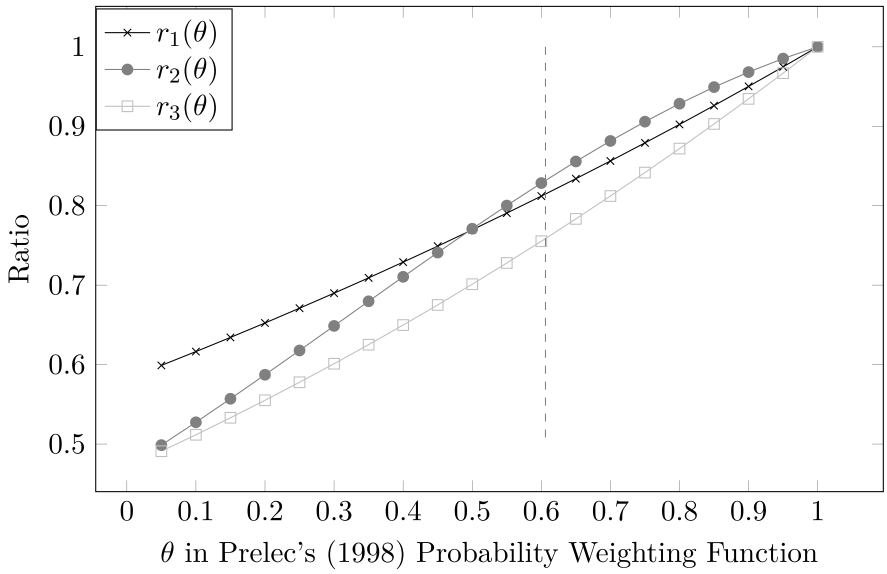



**Fig. B.1:** Ratios of probability weights as functions of $\theta$: control and symmetric background risk treatment

below the ratio $r_1(\theta)$. The optimal investment amount switches at around $\theta = 0.04$ from being on $[0,\frac{2}{3})$ to being on $[\frac{2}{3},1]$. Unlike in the symmetric case, this shift does not change the order of the optimal investment amounts $\delta^*_C$ and $\delta^*_B$. Overall, Figure B.2 indicates that with the skewed multiplicative background risk, more weight is placed on the good investment outcome relative to the bad investment outcome, compared to the control treatment case. Thus, the decision-maker optimally invests a larger proportion of the endowment into the risky asset. This indicates a non-multiplicative risk vulnerable choice.

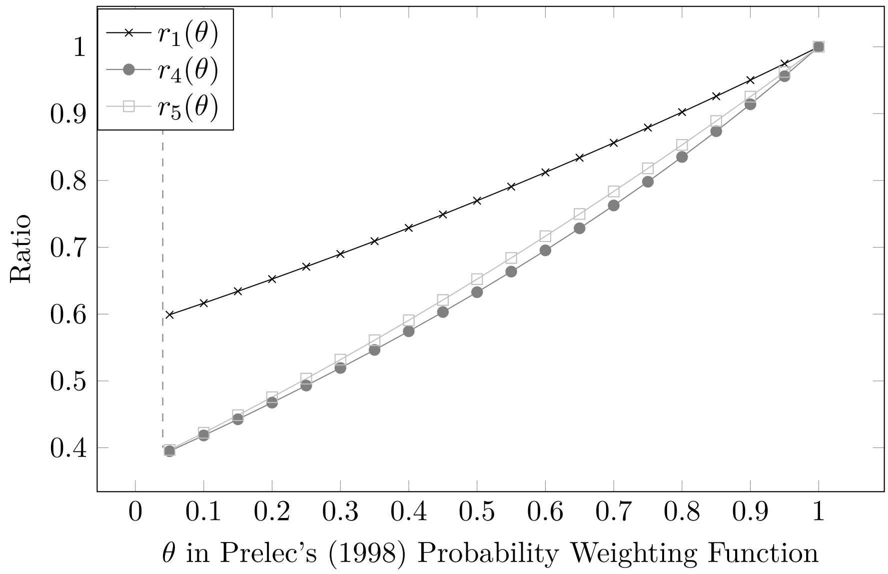



**Fig. B.2:** Ratios of probability weights as functions of $\theta$: control and skewed background risk treatment

# C Experimental Results Including Subjects Who Do Not Touch All Sliders

In this Appendix, we report experimental results including the 29 subjects that we excluded in the main text as these subjects do not touch all sliders in the slider task. We still exclude four subjects who spent substantially less time on the decision screens than everyone else.

## C.1 Summary Statistics

Table C.1 shows summary statistics of individual characteristics of the 330 experiment's subjects.

**Table C.1:** Summary statistics

| | Mean | Minimum | 1st Quartile | Median | 3rd Quartile | Maximum | SD |
|---|---|---|---|---|---|---|---|
| investment_c | 4.26 | 0.00 | 3.00 | 4.00 | 5.50 | 8.00 | (2.25) |
| investment_b | 4.45 | 0.00 | 3.00 | 4.00 | 6.00 | 8.00 | (2.27) |
| age | 25.77 | 19.00 | 23.00 | 25.00 | 28.00 | 58.00 | (4.96) |
| female | 0.64 | | | | | | |
| grq | 4.96 | 1.00 | 3.00 | 5.00 | 7.00 | 10.00 | (2.13) |
| first_time | 0.05 | | | | | | |
| Observations | 330 | | | | | | |

Table C.2 provides summary statistics of the subjects' investment choices split up by whether they are exposed to the skewed (column 1) or the symmetric background risk (column 2). Column 3 shows the difference in means between the different background risks. We compute two-sided Wilcoxon rank sum tests to asses whether the observed differences are statistically significant.

## C.2 Impact of Type of Background Risk

### C.2.1 Skewed Background Risk

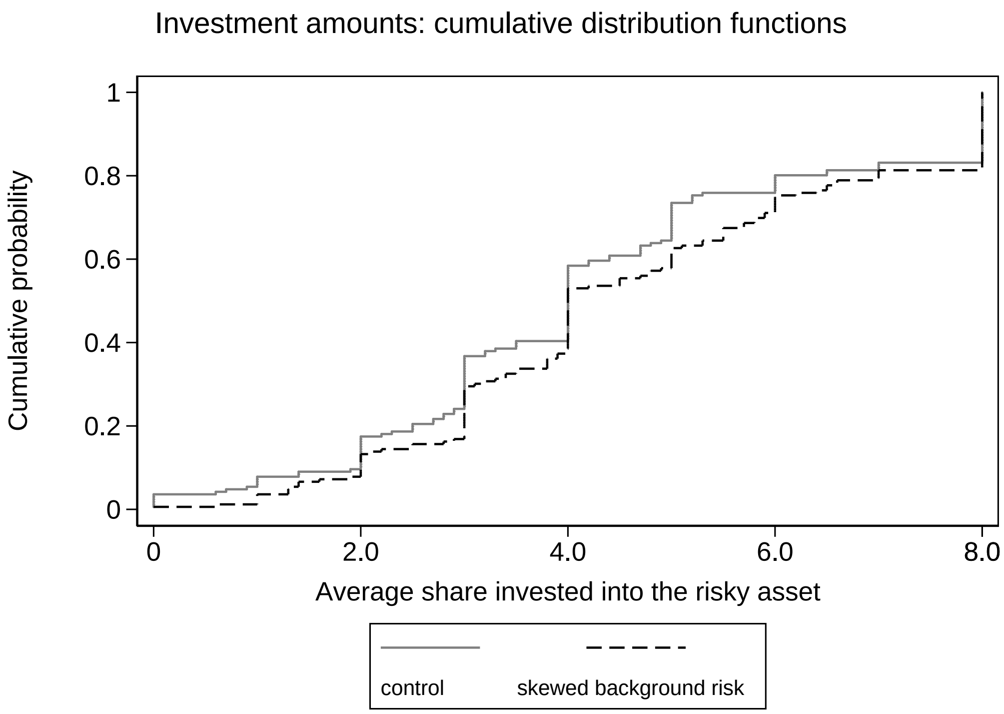



**Fig. C.1:** Cumulative distribution functions of investment amounts, skewed background risk treatment
*Notes: This figure shows the cumulative distribution functions of the investment amounts for the control and the skewed background risk investment games.*

Figure 5 shows the cumulative distribution functions (cdfs) for the investment amounts in the control treatment and the skewed background risk treatment. We observe that the investment amount in the skewed background risk treatment first-order stochastically dominates the investment amount in the control treatment, indicating that these investment amounts are different. We run a Wilcoxon signed-rank test against the null hypothesis that investment amounts are the same. The test rejects the null hypothesis ($p = 0.0306$). This implies that investment amounts

**Table C.2:** Summary by Background Risk

| | Skewed BR | Symmetric BR | Diff |
|---|---|---|---|
| investment_c | 4.280 | 4.242 | 0.038 |
| | (2.211) | (2.291) | |
| investment_b | 4.656 | 4.245 | 0.412* |
| | (2.140) | (2.389) | |
| Age | 25.87 | 25.67 | 0.202 |
| | (5.363) | (4.532) | |
| Female | 0.633 | 0.64 | -0.007 |
| | (0.484) | (0.490) | |
| GRQ | 5.139 | 4.780 | 0.358* |
| | (2.109) | (2.134) | |
| First Time | 0.048 | 0.055 | -0.007 |
| | (0.215) | (0.228) | |
| Law Major | 0.108 | 0.091 | 0.017 |
| | (0.024) | (0.023) | |
| Business Major | 0.133 | 0.079 | 0.053 |
| | (0.026) | (0.021) | |
| Education Major | 0.114 | 0.121 | -0.007 |
| | (0.025) | (0.026) | |
| Humanities Major | 0.120 | 0.159 | -0.038 |
| | (0.025) | (0.028) | |
| Medicine Major | 0.024 | 0.006 | 0.018 |
| | (0.012) | (0.006) | |
| Sciences Major | 0.157 | 0.213 | -0.057 |
| | (0.028) | (0.032) | |
| Social Sciences Major | 0.289 | 0.293 | -0.004 |
| | (0.035) | (0.036) | |
| Other Major | 0.036 | 0.030 | 0.006 |
| | (0.015) | (0.013) | |
| Major not specified | 0.018 | 0.006 | 0.012 |
| | (0.010) | (0.006) | |
| Observations | 166 | 164 | |

*Notes:* mean coefficients; sd in parentheses;
Diff: two-sided Wilcoxon rank-sum test, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

in the skewed background risk treatment are significantly larger than investment amounts in the control treatment.

In Table C.3, we report classification of individuals' choices and the respective investment amounts. 42% of choices in this treatment can be classified as non-risk vulnerable, i.e. the individual invests strictly more in the skewed background risk treatment compared to the control decision. On the other side, approximately 28% of choices are in accordance with multiplicative risk vulnerability. Approximately 30% of the subjects make identical choices with and without background risk. These figures are based on the subsample of subjects that we can classify appropriately. We drop 23 individuals investing the maximum or minimum in both choices and report classification for the reduced sample in Table C.3. In Table D.3 in the Appendix, we include these 23 individuals and consider them to be indifferent.

**Table C.3:** Investment choices and classification - skewed background risk treatment, reduced sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **28.37** | 29.79 | **41.84** | **100** |
| $\delta_C$ (mean) | **4.4325** | 3.4905 | **3.1627** | **4.2801** |
| $\delta_B$ (mean) | **3.2275** | 3.4905 | **5.0373** | **4.6560** |
| No. of Observations | **40** | 40 | **59** | **141** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table excludes individuals who invest the same limiting amount in both choices.

The binomial test rejects the null hypothesis of random behavior ($p = 0.069$). This again provides support of a (marginally) significant effect of the skewed background risk on classification. Accordingly, we observe more non-MRV choices than MRV choices. In addition, investment amounts are significantly larger on aggregate in the presence of the skewed background risk compared to the control investment decision. Thus, we find support of individuals **not** behaving in accordance with multiplicative risk vulnerability in the presence of the skewed background risk.

### C.2.2 Symmetric Background Risk

Figure 6 plots the cumulative distribution functions of the investment amounts in the symmetric background risk treatment and the control treatment. The difference in mean investment amounts is 0.00 EUR (see Table C.2). Consequently, the Wilcoxon signed-rank test fails to reject the null hypothesis of equal investment amount distributions.

Again, we exclude those individuals who cannot be classified because they invest the same limiting amount (31 individuals). We present the classification for this

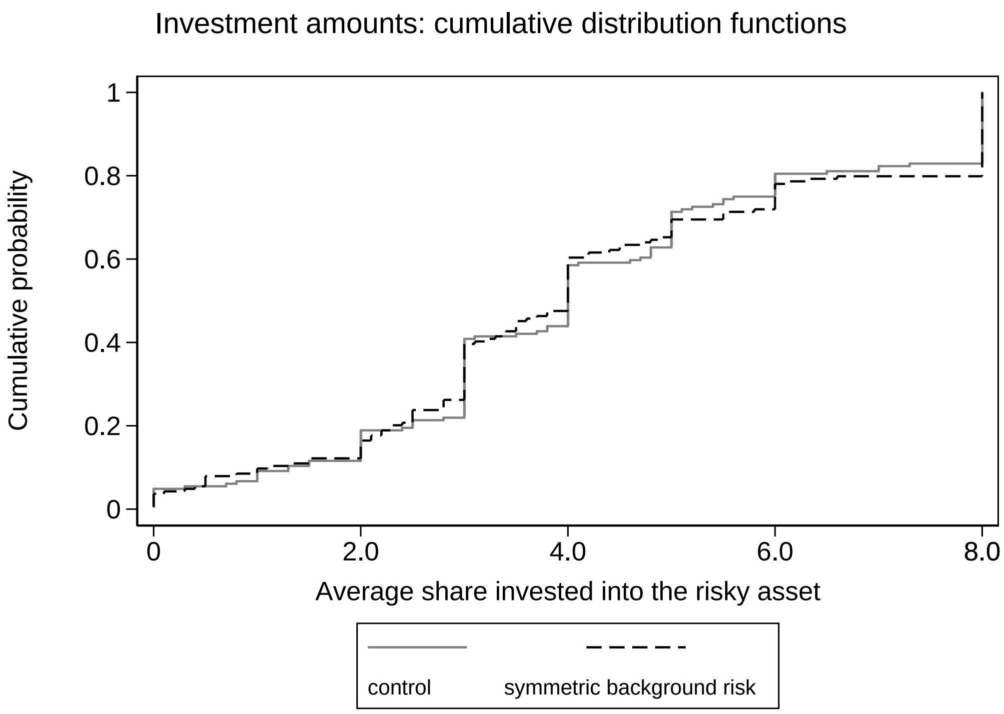



**Fig. C.2:** Cumulative distribution functions of investment amounts, symmetric background risk treatment

*Notes: This figure shows the cumulative distribution functions of the investment amounts for the control and the symmetric background risk investment games.*

reduced sample in Table C.4. A binomial test fails to reject the null hypothesis of random (or indifferent) behavior at any usual significance level ($p = 0.4841$). Overall, our results indicate that, on aggregrate, investment with the symmetric background risk is not different than investment without multiplicative background risk.

### C.2.3 Comparison Skewed and Symmetric Background Risk

Finally, we report the results of the respective probit and OLS regressions in Tables C.5 and C.6. Results are similar to those presented in Tables 7 and 8.

**Table C.4:** Investment choices and classification - symmetric background risk treatment, reduced sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **40.60** | 24.81 | **34.59** | **100** |
| $\delta_C$ (mean) | **4.3630** | 3.7667 | **2.7783** | **3.6669** |
| $\delta_B$ (mean) | **3.0704** | 3.7667 | **4.3043** | **3.6699** |
| No. of Observations | **54** | 33 | **46** | **133** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table excludes individuals who invest the same limiting amount in both choices.

**Table C.5:** Probability to Make a MRV Choice

| | (1)<br>Probit: MRV | (2)<br>Probit: MRV |
|---|---|---|
| Symmetric Background Risk | 0.343* (0.179) | 0.391** (0.188) |
| GRQ | | -0.048 (0.051) |
| Female | | 0.116 (0.218) |
| Non-binary | | 0 (.) |
| Age | | -0.0180 (0.0209) |
| First Time | | 0.339 (0.402) |
| Business Major | | 0.641 (0.404) |
| Education Major | | 0.445 (0.386) |
| Humanities Major | | -0.0110 (0.412) |
| Medicine Major | | 0.219 (0.690) |
| Sciences Major | | -0.0696 (0.375) |
| Social Sciences Major | | -0.198 (0.355) |
| Other Major | | -0.0337 (0.676) |
| Major not specified | | 0.174 (1.045) |
| _cons | -0.243* (0.128) | 0.221 (0.701) |
| $N$ | 199 | 198 |
| Pseudo R-Squared | 0.0555 | 0.0651 |

Dependent Variable: Choice in accordance with strict MRV.

Robust standard errors in parentheses: $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

**Table C.6:** Difference in Investments with and without Background Risk

| | (1) OLS: diff | (2) OLS: diff |
|---|---|---|
| Symmetric Background Risk | 0.373** (0.179) | 0.331* (0.181) |
| GRQ | | -0.0384 (0.0374) |
| Female | | 0.118 (0.204) |
| Non-binary | | 1.029*** (0.258) |
| Age | | -0.0277 (0.0212) |
| First Time | | 0.306 (0.334) |
| Business Major | | 0.164 (0.371) |
| Education Major | | 0.384 (0.361) |
| Humanities Major | | 0.100 (0.327) |
| Medicine Major | | -0.920 (1.465) |
| Sciences Major | | -0.0360 (0.345) |
| Social Sciences Major | | 0.109 (0.316) |
| Other Major | | -0.833 (0.839) |
| Major not specified | | 0.284 (0.363) |
| _cons | -0.376*** (0.134) | 0.393 (0.612) |
| $N$ | 330 | 330 |
| R-Squared | 0.0131 | 0.0491 |

Difference in investment amounts with and without background risk treatment.
Robust standard errors in parentheses: $^{*}$ $p < 0.10$, $^{**}$ $p < 0.05$, $^{***}$ $p < 0.01$

# D Additional Tables

**Table D.1:** Investment choices and classification - skewed background risk treatment: Main Text Sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **22.8** | 39.60 | **37.59** | **100** |
| $\delta_C$ (mean) | **4.2235** | 5.1966 | **3.0910** | **4.1832** |
| $\delta_B$ (mean) | **3.1147** | 5.1966 | **4.9875** | **4.6430** |
| No. of Observations | **34** | 59 | **56** | **149** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table includes subjects that invest the same limiting amount in both investment decisions and classifies these individuals as indifferent.

**Table D.2:** Investment choices and classification - symmetric background risk treatment: Main Text Sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **32.89** | 38.16 | **28.95** | **100** |
| $\delta_C$ (mean) | **4.2560** | 5.1778 | **2.7341** | **4.1671** |
| $\delta_B$ (mean) | **2.9320** | 5.1778 | **4.2727** | **4.1770** |
| No. of Observations | **50** | 58 | **44** | **152** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table includes subjects that invest the same limiting amount in both investment decisions and classifies these individuals as indifferent.

**Table D.3:** Investment choices and classification - skewed background risk treatment: Appendix C Sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **24.10** | 40.36 | **35.54** | **100** |
| $\delta_C$ (mean) | **4.4325** | 5.1731 | **3.1627** | **4.2801** |
| $\delta_B$ (mean) | **3.2275** | 5.1731 | **5.0373** | **4.6560** |
| No. of Observations | **40** | 67 | **59** | **166** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table includes subjects that invest the same limiting amount in both investment decisions and classifies these individuals as indifferent.

**Table D.4:** Investment choices and classification - symmetric background risk treatment: Appendix C Sample

| Classification | **Strictly Mult. RV** | Indifferent | **Non Mult. RV** | **All** |
|---|---|---|---|---|
| Frequency (%) | **32.93** | 39.02 | **28.05** | **100** |
| $\delta_C$ (mean) | **4.3630** | 5.1922 | **2.7783** | **4.2421** |
| $\delta_B$ (mean) | **3.0704** | 5.1922 | **4.3043** | **4.2445** |
| No. of Observations | **54** | 64 | **46** | **164** |

*Notes:* Strictly Mult. RV: Strictly multiplicative risk vulnerable choice; Indifferent: same investment amount in both choices; Non Mult. RV: Non-multiplicative risk vulnerable choice. This table includes subjects that invest the same limiting amount in both investment decisions and classifies these individuals as indifferent.

# E Experimental Instructions

***(translated from German)***

## E.1 Introduction

Thank you for your participation in this experiment! We recommend activating full screen mode in your browser (in Chrome, Firefox and Edge: F11) while performing the experiment. This experiment consists of five sections.

The first section will be a slider task. In the second and third section, you will make investment decisions. In the fourth section, we will ask you some socio-demographic questions in a questionnaire. In the fifth section, your compensation will be determined.

You can see the sequence of each section of the experiment in the diagram above. Please take enough time to complete each section to the best of your ability. You will have sufficient time to complete all sections. On average, it will take participants 25 minutes to complete the experiment. Please note that the maximum completion time is 60 minutes. Exceeding the maximum completion time will result in you not receiving any compensation. Therefore, we recommend that you complete the experiment without interruptions after pressing the start button.

In this study, we investigate factors influencing risky investment decisions.

During the experiment, we will collect data anonymously for scientific purposes. We will not associate this data with you personally. Please do not share information about this experiment with anyone else.

(Next page)

## E.2 Information on Compensation

In this experiment, you will make investment decisions in two different scenarios. One of these two scenarios will be randomly drawn and played out at the end of the experiment. Accordingly, you will receive a compensation depending on your decisions and the randomness. In total, the compensation ranges between 0 EUR and 24 EUR (28 EUR).

Please consider your decisions carefully during the experiment. Each of your decisions can influence your actual payout.

By clicking on the following button you start the experiment and the maximum completion time of 60 minutes begins.

(Next page)

## E.3 Slider Task

Below you will see a total of 20 sliders. Your task is to position the 20 sliders as close to the center of the respective scale as possible. You have a total of 3 minutes.

(Next page)

Figure F.3 shows the Slider Task.

## E.4 Information on Investment Decisions

There will be two scenarios below, each of which requires you to make an investment decision. Please read the presentation of the scenarios carefully.

On the following two pages, you can set your decision with a slider in each case. By moving the slider, you will see in real time how your potential payouts change depending on your investment amount.

One of the two scenarios is randomly drawn at the end of the experiment (each with a probability of 1/2) and played out. Your decisions will affect your possible payout at the end of the experiment. We therefore recommend that you consider your decisions carefully.

(Next page)

## E.5 Control Treatment

You receive a starting capital of 8.00 EUR.

You can decide how much of your starting capital you want to invest. You can invest between 0.00 EUR and 8.00 EUR. With a probability of 5/10 your investment is successful and worth 2.5 times as much. With a probability of 5/10 your investment is not successful and you lose the invested amount. The uninvested amount is not exposed to any investment risk.

You can see the possible payouts depending on the amount you invested below. You can set the amount using the slider.

Please indicate how much you would like to invest (from 0.00 EUR to 8.00 EUR).

(Slider)

Investing this amount results in the following possible payouts:

Positive (negative) investment result (probability 5/10):

If the investment is (not) successful, your assets will be (Asset).

(Next page)

## E.6 Background Risk Treatment

You receive a starting capital of 8.00 EUR.

First, you can decide how much of your starting capital you want to invest. You can invest between 0.00 EUR and 8.00 EUR. With a probability of 5/10 your investment is successful and worth 2.5 times as much as before. With a probability of 5/10 your investment is not successful and you lose the invested amount. The uninvested amount is not exposed to any investment risk.

In a second step, after the investment has been paid out, your assets are subject to another, independent risk. With a probability of 8/10 (5/10) your assets will gain 20% (40%) in value, with a probability of 2/10 (5/10) your assets will lose 80% (40%) in value. This risk is shown below in the form of a pie chart.

You can see below the possible payouts depending on the amount you invest. You can set the amount using the slider.

Please indicate how much you would like to invest (from 0.00 EUR to 8.00 EUR).

(Slider)

Investing this amount results in the following possible payouts:

Positive (negative) investment result (probability 5/10):

If the investment is (not) successful, your assets will be (Asset). This amount of (Asset) is subject to a second risk. With a probability of 8/10 (5/10) your assets will gain 20% (40%) in value, with a probability of 2/10 (5/10) your assets will lose 80% (40%) in value. You can see the possible final amounts in the following pie chart.

(Pie Charts)

(Next page)

### E.7 Questionnaire

Please answer the following questions.

- What is your age?
- What is your gender?
- Is this your first participation in a social science experiment?
- What is your highest level of education?
- What is your major studies?
- How do you rate yourself personally? Are you generally a risk-seeking person or are you trying to avoid risks? Please answer using the following scale with 0 (completely unwilling to take risks) and 10 (completely willing to take risks). With the values in between, you can graduate your assessment.

### E.8 Payoff

In the following table you can see an overview of the rounds played. (First column: round, second: amount invested, third and fourth: Payout in case of profit and loss) (Table)

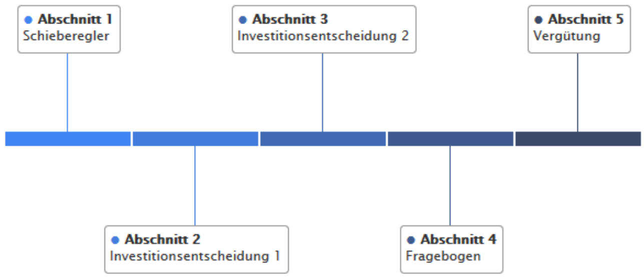
Round 1 (2) was randomly selected to determine your payout.

For the selected round, one of the two possible outcomes of your investment decision was randomly realized based on the corresponding probabilities (50% each). (Subsequently, the additional risk was randomly realized according to the corresponding probabilities.)
Your investment was (not) successful. In this case, your assets were (not) subject to any additional risk.
(The result of the additional risk is negative (positive). Your assets are reduced (increased) by 40% (20% or 80%)). Your total payout is therefore (Payoff).

## F Screenshots of the Experiment

# Allgemeine Informationen

Ablauf des Experiments




Vielen Dank für Ihre Teilnahme an diesem Experiment! Wir empfehlen während der Durchführung des Experiments den Vollbild-Modus in Ihrem Browser zu aktivieren (in Chrome, Firefox und Edge: F11). Dieses Experiment besteht aus fünf Abschnitten.

Im ersten Abschnitt erhalten Sie eine Aufgabe zur Einstellung von Schiebereglern. Im zweiten und dritten Abschnitt werden Sie Investitionsentscheidungen treffen. Im vierten Abschnitt erheben wir einige persönliche Daten in einem Fragebogen. Im fünften Abschnitt wird Ihre Vergütung bestimmt.

Sie sehen die Abfolge der einzelnen Abschnitte des Experiments oben im Ablaufplan. Bitte nehmen Sie sich genügend Zeit, um jeden Abschnitt nach bestem Wissen und Gewissen zu bearbeiten. Sie werden ausreichend viel Zeit haben, um alle Abschnitte zu beantworten. Im Durchschnitt benötigen die Teilnehmer zur vollständigen Durchführung des Experiments **25 Minuten**. Bitte beachten Sie, dass die maximale Bearbeitungszeit **60 Minuten** beträgt. Überschreitungen der maximalen Bearbeitungszeit führen dazu, dass Sie **keine Vergütung** erhalten. Deshalb empfehlen wir Ihnen, das Experiment nach dem Drücken des Start-Buttons **ohne Unterbrechungen** durchzuführen.

In dieser Studie untersuchen wir Einflussfaktoren von riskanten Investitionsentscheidungen.

Während des Experiments werden wir zu wissenschaftlichen Zwecken Daten anonym erheben. Diese Daten werden wir nicht mit Ihnen persönlich in Verbindung bringen. Bitte teilen Sie keine Informationen über dieses Experiment mit anderen Personen.

Weiter

**Fig. F.1:** Introduction

# Informationen zur Vergütung

In diesem Experiment treffen Sie Investitionsentscheidungen in **zwei** verschiedenen Szenarien. **Eines** dieser beiden Szenarien wird am Ende des Experiments zufällig ausgelost und ausgespielt. Sie erhalten demnach eine Vergütung **in Abhängigkeit Ihrer Entscheidungen** und des Zufalls. Insgesamt liegt die Vergütung zwischen 0 € und 24 €.

Bitte überlegen Sie sich Ihre Entscheidungen während des Experiments gut. Jede Ihrer Entscheidungen kann Ihre tatsächliche Auszahlung beeinflussen.

Mit einem Klick auf den folgenden Button starten Sie das Experiment und die maximale Bearbeitungszeit von 60 Minuten beginnt.

**Fig. F.2:** Information on Compensation (skewed background risk treatment)

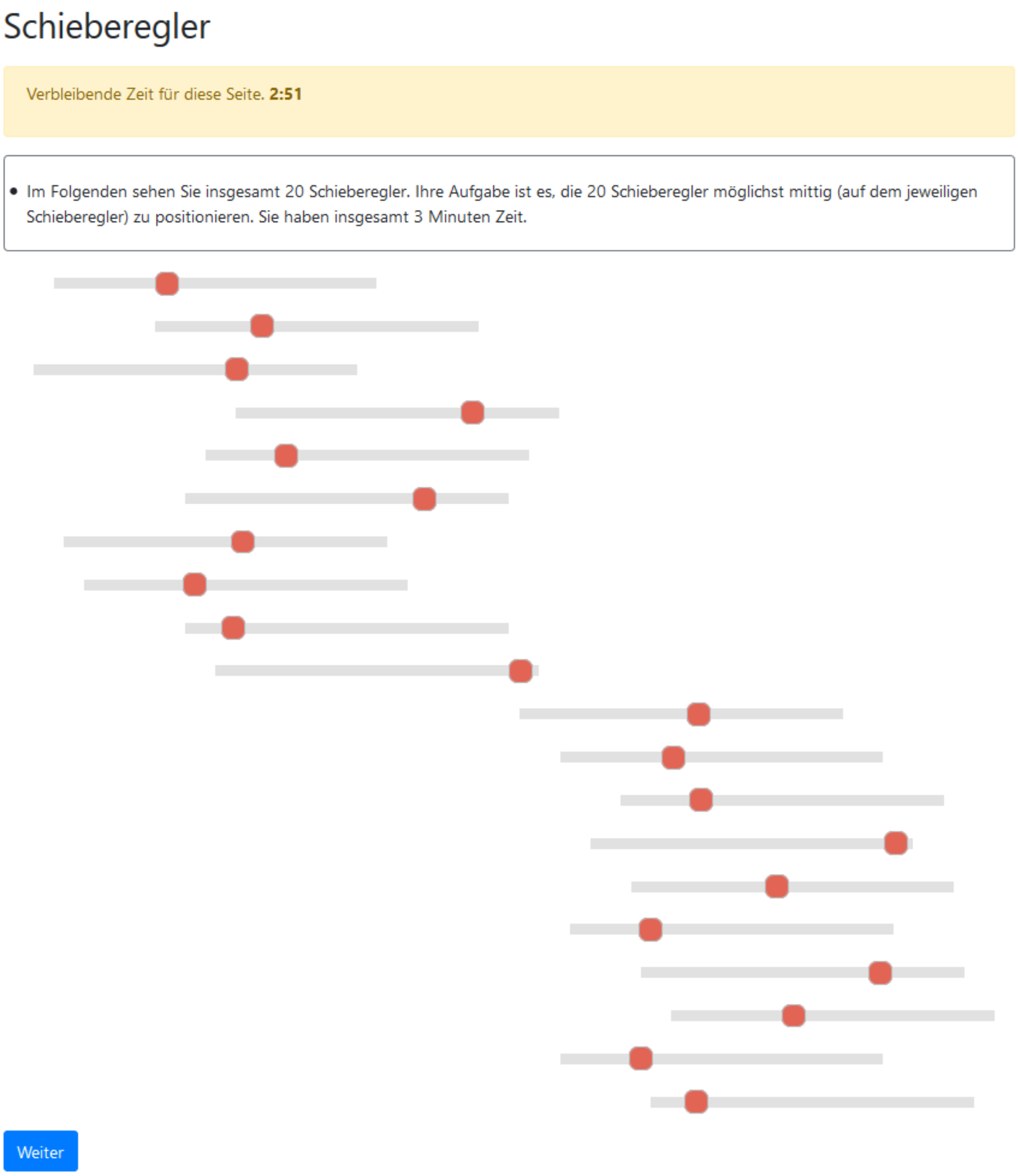



**Fig. F.3:** Slider task

## Informationen zu den Investitionsentscheidungen

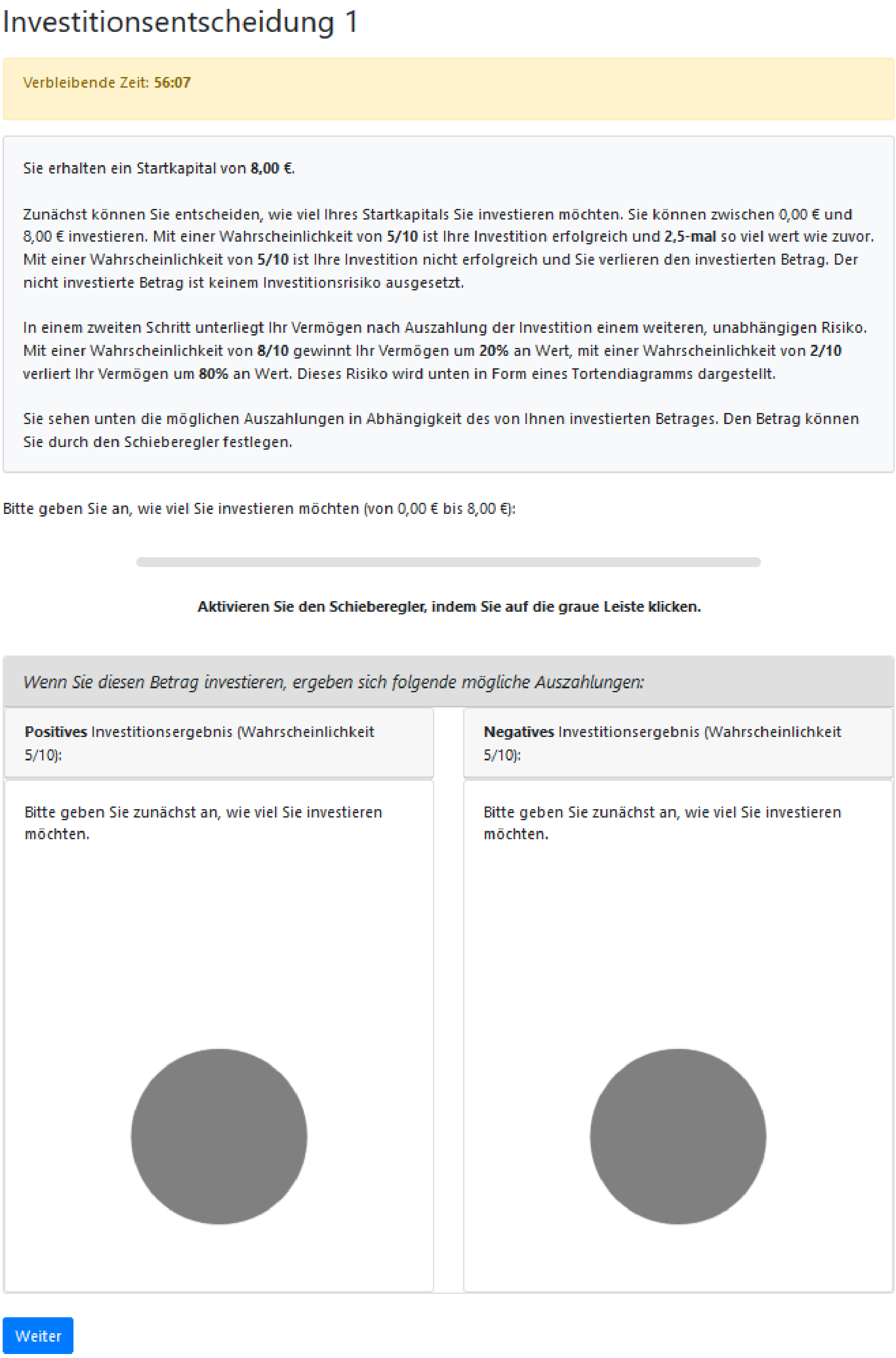
Verbleibende Zeit: **57:59**

Ihnen werden im Folgenden **zwei** Szenarien vorgestellt, in denen Sie jeweils eine Investitionsentscheidung treffen müssen. Bitte lesen Sie sich die Darstellung der Szenarien genau durch.

Auf den folgenden zwei Seiten können Sie Ihre Entscheidungen jeweils mit einem **Schieberegler** festlegen. Durch das Bewegen des Schiebereglers sehen Sie in Echtzeit, wie sich Ihre möglichen Auszahlungen in Abhängigkeit Ihrer Investitionssumme verändern.

Eines der beiden Szenarien wird am Ende des Experiments zufällig ausgelost (jeweils mit einer Wahrscheinlichkeit von 1/2) und ausgespielt. Ihre Entscheidungen beeinflussen Ihre mögliche **Auszahlung** am Ende des Experiments. Wir empfehlen Ihnen daher, Ihre Entscheidungen gut zu überlegen.

**Fig. F.4:** Information on Investment Decisions



# Investitionsentscheidung 1

Verbleibende Zeit: **56:07**

Sie erhalten ein Startkapital von **8,00 €**.

Zunächst können Sie entscheiden, wie viel Ihres Startkapitals Sie investieren möchten. Sie können zwischen 0,00 € und 8,00 € investieren. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition erfolgreich und **2,5-mal** so viel wert wie zuvor. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition nicht erfolgreich und Sie verlieren den investierten Betrag. Der nicht investierte Betrag ist keinem Investitionsrisiko ausgesetzt.

In einem zweiten Schritt unterliegt Ihr Vermögen nach Auszahlung der Investition einem weiteren, unabhängigen Risiko. Mit einer Wahrscheinlichkeit von **8/10** gewinnt Ihr Vermögen um **20%** an Wert, mit einer Wahrscheinlichkeit von **2/10** verliert Ihr Vermögen um **80%** an Wert. Dieses Risiko wird unten in Form eines Tortendiagramms dargestellt.

Sie sehen unten die möglichen Auszahlungen in Abhängigkeit des von Ihnen investierten Betrages. Den Betrag können Sie durch den Schieberegler festlegen.

Bitte geben Sie an, wie viel Sie investieren möchten (von 0,00 € bis 8,00 €):

**Aktivieren Sie den Schieberegler, indem Sie auf die graue Leiste klicken.**

*Wenn Sie diesen Betrag investieren, ergeben sich folgende mögliche Auszahlungen:*

**Positives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

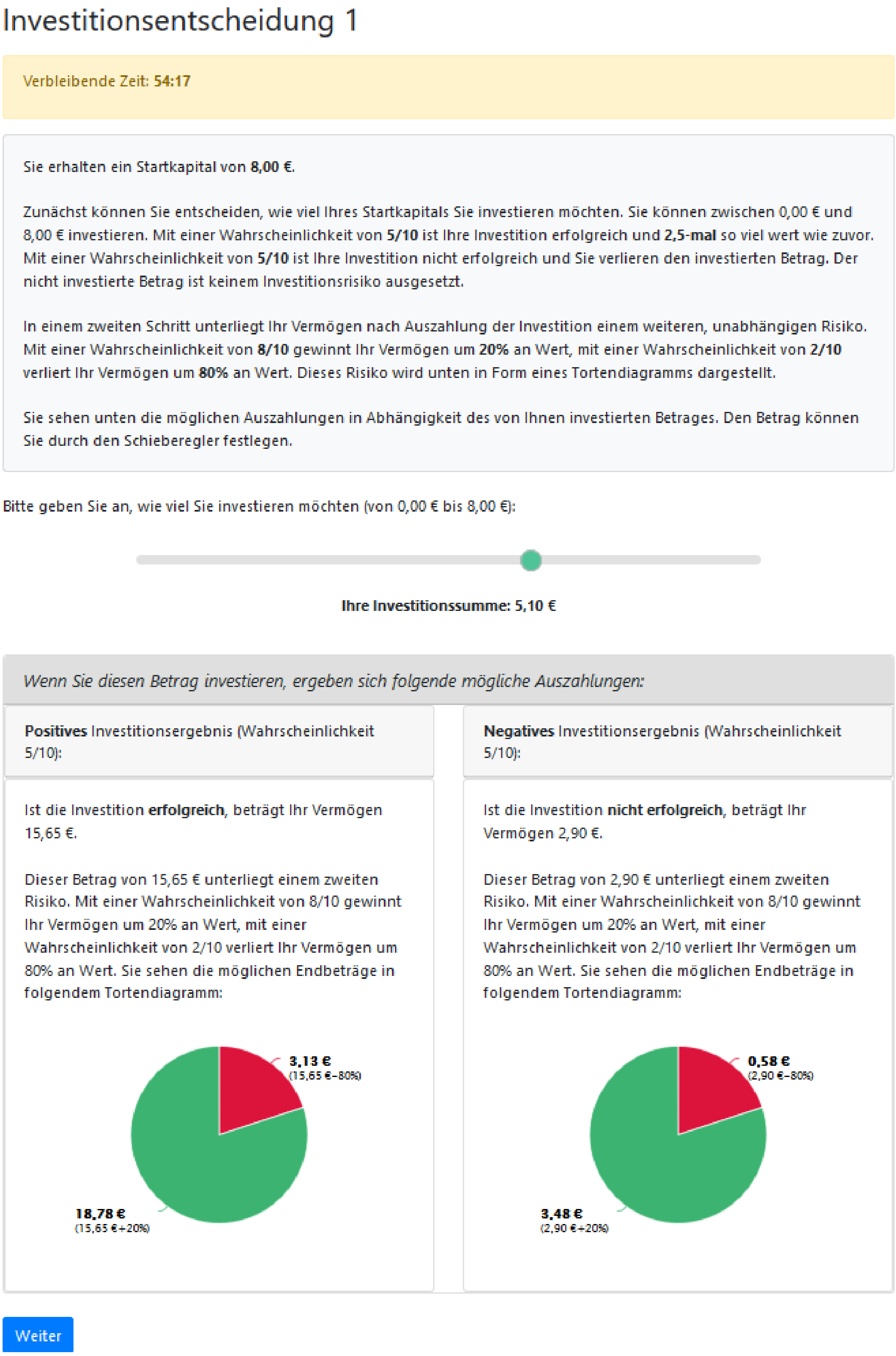
Bitte geben Sie zunächst an, wie viel Sie investieren möchten.

**Negatives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

Bitte geben Sie zunächst an, wie viel Sie investieren möchten.

Weiter

**Fig. F.5:** Investment Decision with Skewed Background Risk Prior to Activating the Slider



# Investitionsentscheidung 1

Verbleibende Zeit: **54:17**

Sie erhalten ein Startkapital von **8,00 €**.

Zunächst können Sie entscheiden, wie viel Ihres Startkapitals Sie investieren möchten. Sie können zwischen 0,00 € und 8,00 € investieren. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition erfolgreich und **2,5-mal** so viel wert wie zuvor. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition nicht erfolgreich und Sie verlieren den investierten Betrag. Der nicht investierte Betrag ist keinem Investitionsrisiko ausgesetzt.

In einem zweiten Schritt unterliegt Ihr Vermögen nach Auszahlung der Investition einem weiteren, unabhängigen Risiko. Mit einer Wahrscheinlichkeit von **8/10** gewinnt Ihr Vermögen um **20%** an Wert, mit einer Wahrscheinlichkeit von **2/10** verliert Ihr Vermögen um **80%** an Wert. Dieses Risiko wird unten in Form eines Tortendiagramms dargestellt.

Sie sehen unten die möglichen Auszahlungen in Abhängigkeit des von Ihnen investierten Betrages. Den Betrag können Sie durch den Schieberegler festlegen.

Bitte geben Sie an, wie viel Sie investieren möchten (von 0,00 € bis 8,00 €):

**Ihre Investitionssumme: 5,10 €**

*Wenn Sie diesen Betrag investieren, ergeben sich folgende mögliche Auszahlungen:*

**Positives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

Ist die Investition **erfolgreich**, beträgt Ihr Vermögen 15,65 €.

Dieser Betrag von 15,65 € unterliegt einem zweiten Risiko. Mit einer Wahrscheinlichkeit von 8/10 gewinnt Ihr Vermögen um 20% an Wert, mit einer Wahrscheinlichkeit von 2/10 verliert Ihr Vermögen um 80% an Wert. Sie sehen die möglichen Endbeträge in folgendem Tortendiagramm:



**Negatives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

Ist die Investition **nicht erfolgreich**, beträgt Ihr Vermögen 2,90 €.

Dieser Betrag von 2,90 € unterliegt einem zweiten Risiko. Mit einer Wahrscheinlichkeit von 8/10 gewinnt Ihr Vermögen um 20% an Wert, mit einer Wahrscheinlichkeit von 2/10 verliert Ihr Vermögen um 80% an Wert. Sie sehen die möglichen Endbeträge in folgendem Tortendiagramm:



Weiter

**Fig. F.6:** Investment Decision with Skewed Background Risk After Activating the Slider

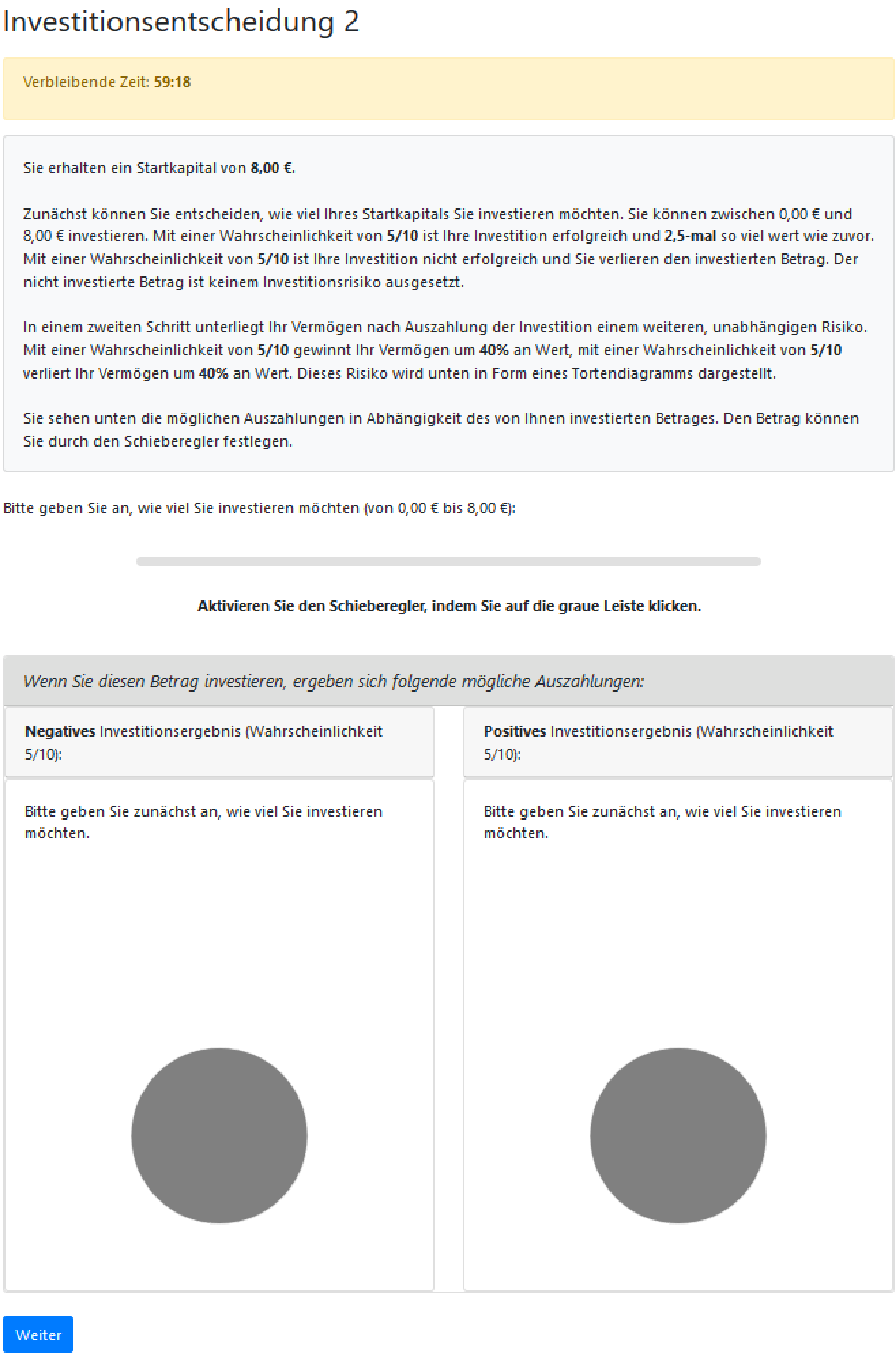
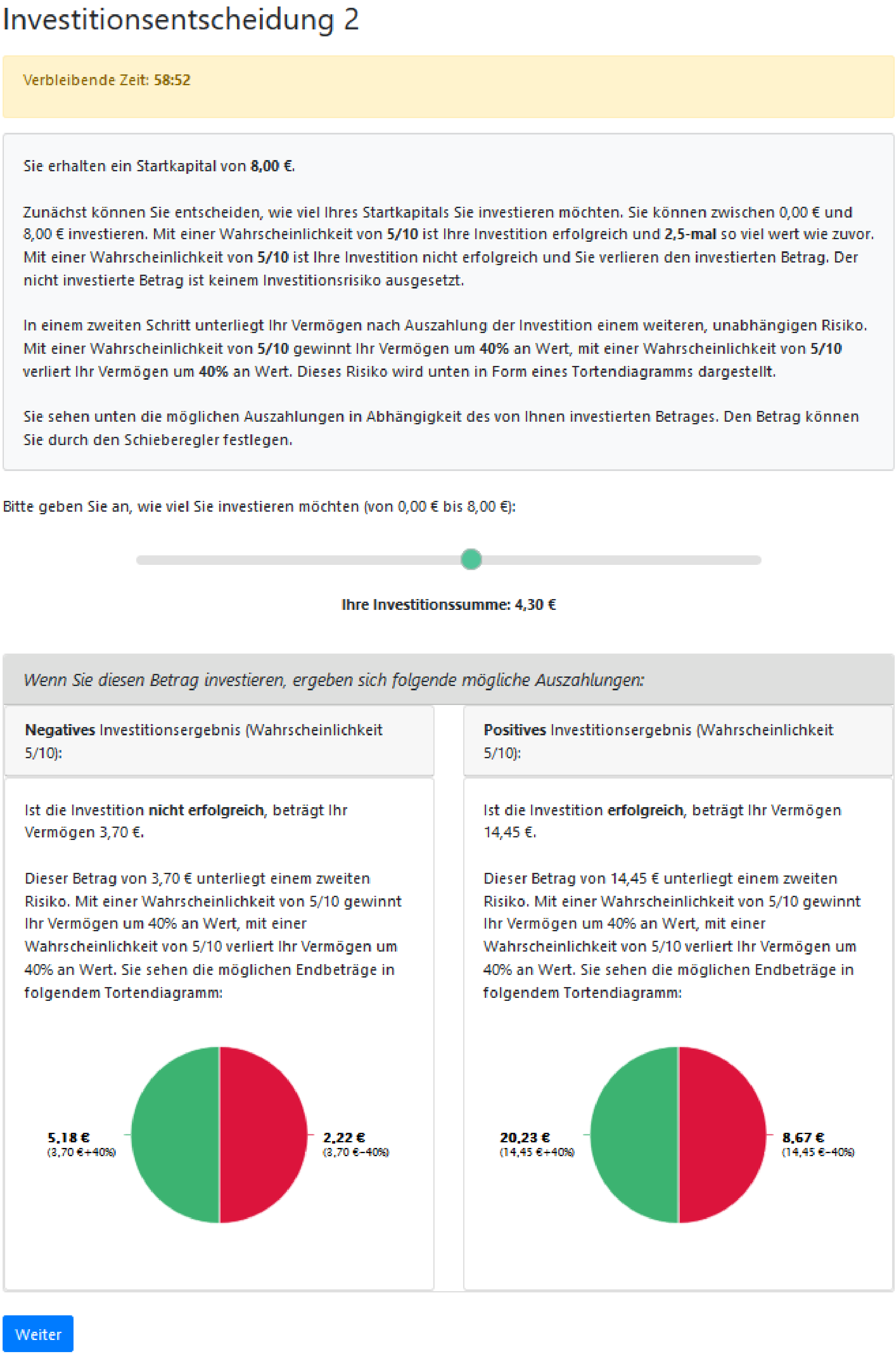



**Fig. F.7:** Investment Decision with Symmetric Background Risk Prior to Activating the Slider



## Investitionsentscheidung 2

Verbleibende Zeit: **58:52**

Sie erhalten ein Startkapital von **8,00 €**.

Zunächst können Sie entscheiden, wie viel Ihres Startkapitals Sie investieren möchten. Sie können zwischen 0,00 € und 8,00 € investieren. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition erfolgreich und **2,5-mal** so viel wert wie zuvor. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition nicht erfolgreich und Sie verlieren den investierten Betrag. Der nicht investierte Betrag ist keinem Investitionsrisiko ausgesetzt.

In einem zweiten Schritt unterliegt Ihr Vermögen nach Auszahlung der Investition einem weiteren, unabhängigen Risiko. Mit einer Wahrscheinlichkeit von **5/10** gewinnt Ihr Vermögen um **40%** an Wert, mit einer Wahrscheinlichkeit von **5/10** verliert Ihr Vermögen um **40%** an Wert. Dieses Risiko wird unten in Form eines Tortendiagramms dargestellt.

Sie sehen unten die möglichen Auszahlungen in Abhängigkeit des von Ihnen investierten Betrages. Den Betrag können Sie durch den Schieberegler festlegen.

Bitte geben Sie an, wie viel Sie investieren möchten (von 0,00 € bis 8,00 €):

**Ihre Investitionssumme: 4,30 €**

*Wenn Sie diesen Betrag investieren, ergeben sich folgende mögliche Auszahlungen:*

**Negatives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

Ist die Investition **nicht erfolgreich**, beträgt Ihr Vermögen 3,70 €.

Dieser Betrag von 3,70 € unterliegt einem zweiten Risiko. Mit einer Wahrscheinlichkeit von 5/10 gewinnt Ihr Vermögen um 40% an Wert, mit einer Wahrscheinlichkeit von 5/10 verliert Ihr Vermögen um 40% an Wert. Sie sehen die möglichen Endbeträge in folgendem Tortendiagramm:

**5,18 €** (3,70 €+40%)
**2,22 €** (3,70 €−40%)

**Positives** Investitionsergebnis (Wahrscheinlichkeit 5/10):

Ist die Investition **erfolgreich**, beträgt Ihr Vermögen 14,45 €.

Dieser Betrag von 14,45 € unterliegt einem zweiten Risiko. Mit einer Wahrscheinlichkeit von 5/10 gewinnt Ihr Vermögen um 40% an Wert, mit einer Wahrscheinlichkeit von 5/10 verliert Ihr Vermögen um 40% an Wert. Sie sehen die möglichen Endbeträge in folgendem Tortendiagramm:

**20,23 €** (14,45 €+40%)
**8,67 €** (14,45 €−40%)

Weiter

**Fig. F.8:** Investment Decision with Symmetric Background Risk After Activating the Slider

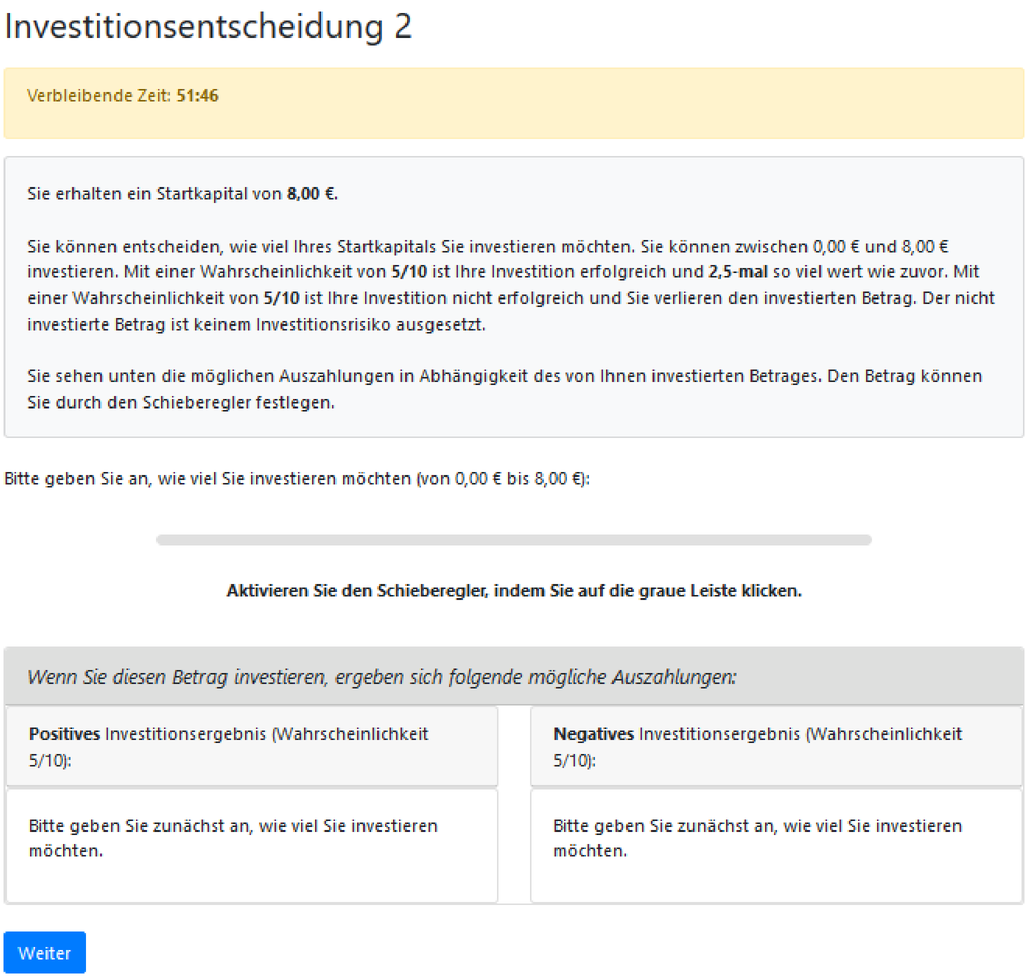
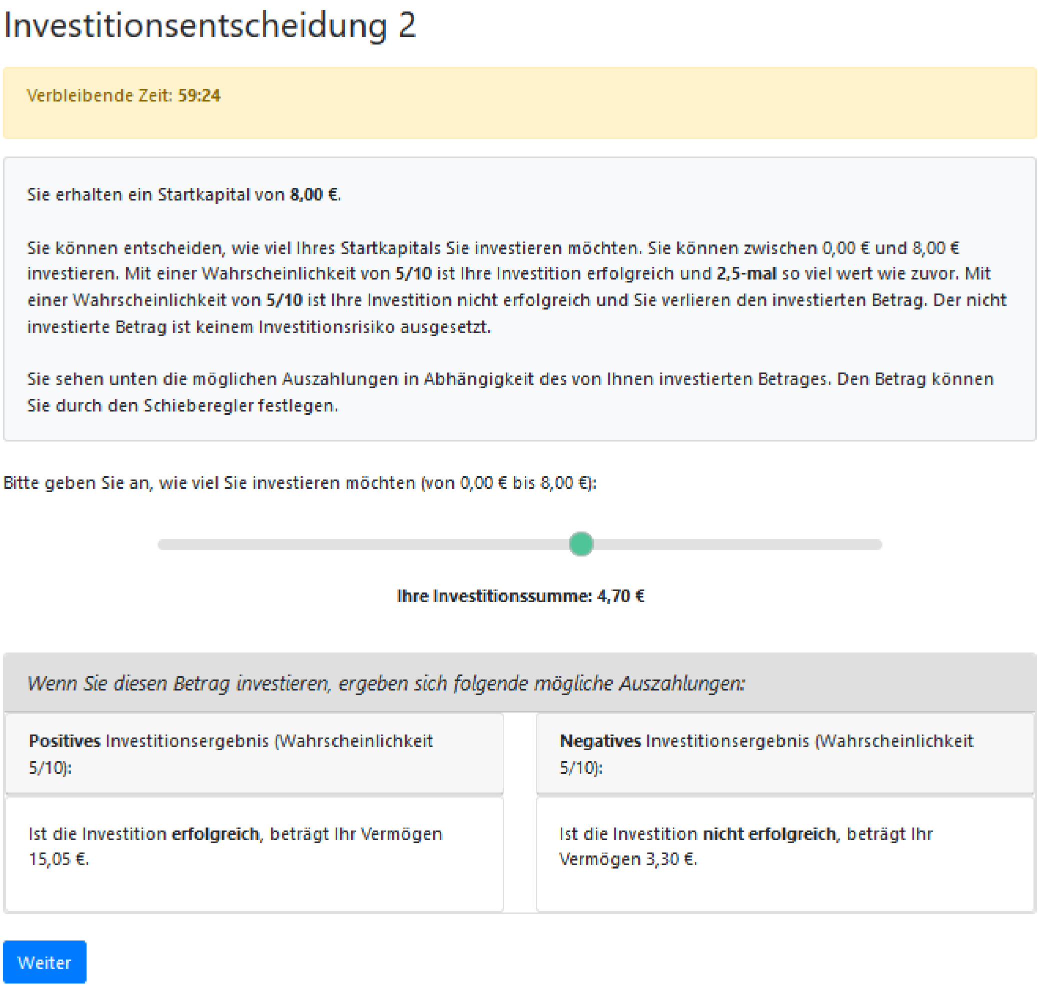



**Fig. F.9:** Investment Decision without Background Risk Prior to Activating the Slider



## Investitionsentscheidung 2

Verbleibende Zeit: **59:24**

Sie erhalten ein Startkapital von **8,00 €**.

Sie können entscheiden, wie viel Ihres Startkapitals Sie investieren möchten. Sie können zwischen 0,00 € und 8,00 € investieren. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition erfolgreich und **2,5-mal** so viel wert wie zuvor. Mit einer Wahrscheinlichkeit von **5/10** ist Ihre Investition nicht erfolgreich und Sie verlieren den investierten Betrag. Der nicht investierte Betrag ist keinem Investitionsrisiko ausgesetzt.

Sie sehen unten die möglichen Auszahlungen in Abhängigkeit des von Ihnen investierten Betrages. Den Betrag können Sie durch den Schieberegler festlegen.

Bitte geben Sie an, wie viel Sie investieren möchten (von 0,00 € bis 8,00 €):

**Ihre Investitionssumme: 4,70 €**

*Wenn Sie diesen Betrag investieren, ergeben sich folgende mögliche Auszahlungen:*

| **Positives** Investitionsergebnis (Wahrscheinlichkeit 5/10): | **Negatives** Investitionsergebnis (Wahrscheinlichkeit 5/10): |
|---|---|
| Ist die Investition **erfolgreich**, beträgt Ihr Vermögen 15,05 €. | Ist die Investition **nicht erfolgreich**, beträgt Ihr Vermögen 3,30 €. |

Weiter

**Fig. F.10:** Investment Decision without Background Risk After Activating the Slider

# Vergütung

In der folgenden Tabelle sehen Sie eine Übersicht über die gespielten Runden:

| Runde | investierter Betrag | Auszahlung im Gewinnfall | Auszahlung im Verlustfall |
|---|---|---|---|
| 1 | 5,10 € | 15,65 € + zusätzliches Risiko | 2,90 € + zusätzliches Risiko |
| 2 | 4,70 € | 15,05 € | 3,30 € |

Für die Bestimmung Ihrer Auszahlung wurde zufällig **Runde 2** ausgewählt.

Für die ausgewählte Runde wurde eines der beiden möglichen Ergebnisse Ihrer Investitionsentscheidung zufällig auf der Grundlage der entsprechenden Wahrscheinlichkeiten (jeweils 50%) realisiert.

Ihre Investition war nicht erfolgreich. In diesem Fall unterlag Ihr Vermögen keinem zusätzlichen Risiko. Ihre gesamte Auszahlung beträgt somit **3,30 €**.

Weiter

**Fig. F.11:** Determination of Payoff