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On the Impact of Risky Private and Public Returns in the Private Provision of Public Goods – The Case of Social Investments

Abstract

We use a laboratory experiment to identify the impact of risk in the private and public dimensions of social investments. In variants of a public good game, we separate the return a subject's investment generates for herself vs. the return to others. We find a detrimental effect of risk on public good provision when returns in both dimensions are risky and positively correlated or independent. A negative correlation limits the downside risk and leads to more stable social investments. Disentangling the impact of risk in the two dimensions, we find that investments particularly respond to the risk in the public return dimension.

JEL-Codes: C910, D640, D810, H410.

Keywords: social investments, public goods, giving under risk, correlated risks.

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1 Introduction

The benefits from investments in public goods are often uncertain. While a large literature considers how voluntary contributions are impacted by uncertainty regarding the benefits from public goods (e.g., Dickinson, 1998; Levati et al., 2009; Théroude and Zylbersztejn, 2017), it mostly focuses on situations where those uncertain benefits accrue to all, that is the return to an individual contributor and to the rest of society are fully correlated. In this paper we argue that it is important to additionally investigate settings that separate the impact of a subject's decision on her *own* payoff from the return that *others* receive from this investment. Based on a laboratory experiment, we explore how pro-social behavior depends on the risk in these two dimensions of the investment good as well as their interactions.

We consider this a more realistic setting for a wide range of applications given the frequent simultaneous presence of risk in private and social returns. An important example are social investments, i.e. investment activities that have in expectation both a social return and a private financial return. The trend to use "repayable finance to achieve a social as well as a financial return" has been widely recognized in Western societies (e.g., Warner, 2013, p.5). In the U.S., for example, social investments have seen an estimated growth of 33% from 2014 to 2016 alone and amounted to 8.72 trillion dollars at the beginning of 2016, thereby benefiting charities as well as social enterprises (see Voorhes and Humphreys, 2016). More generally, any impure public good (e.g., Andreoni, 1990; Cornes and Sandler, 1994; Kotchen, 2005; Chan and Kotchen, 2014) separately considers private returns and returns to the public good and the demand for these "bundled" goods is determined by the private benefit as well as a possible warm-glow sensation derived from the latter. Likewise, microlending and crowdinvesting have emerged as popular means to provide public goods.

Through investigating how investments depend on the presence of risks in private or public returns and in particular on the correlation between these risks, our results may lend insights into these two ways of privately providing (impure) public goods. Here, investors can either get a fixed private return or, e.g., get repaid depending on the success of the project. If the public benefit—imagine the environmental benefits of a new technology to clean water—realizes together with the financial success of the project, this suggests a positive correlation between private and public returns. In other instances, the realization of the public benefit may partly depend on exogenous environmental determinants, whereas the private return to the investor may be secured by financial and managerial skills, in which case the risks are imperfectly correlated or independent. Conversely, our negative correlation treatment bears similarities with pledging an investment which is only deducted if the project materializes. Our findings suggest that a reduction of risk in the social domain is particularly important, both in the presence and in the absence of risk in private returns.

Our experimental design first identifies the effect of the *simultaneous* presence of risks in both private and public returns on contribution choices over time. We find a similarly detrimental effect of risk when returns in the two dimensions are positively correlated or independent. This similarity suggests that subjects' behavior might be particularly driven by the downside risk, i.e. the possibility that investments may generate neither a private nor a public return. When both returns are negatively correlated, this downside risk is alleviated and, indeed, we find that investments are more stable. Second, we disentangle the importance of risk in either dimension. The results show that, even though investments are slightly reduced when private returns are risky, investments particularly respond to risk in the public return dimension. By eliciting individuals' risk preferences towards own and others' payoffs,[1] we further show that treatment differences are driven by risk-averse types.

The role of risk in prosocial decisions has been investigated in different strands of the literature. In non-strategic two-person interactions, the impact of risk on giving decisions has been shown by, e.g. Dana et al. (2007), Andreoni and Bernheim (2009), Krawczyk and Le Lec (2010) and Brock et al. (2013).[2] Within the literature on charitable donations, for example, Potters

[1]Several studies compare risk attitudes when making a decision about own payoff vs. the payoff of another person or the payoff of the group. Evidence of the arising biases appears mixed. Harrison et al. (2013) find more risk-aversion in groups compared to individual decisions, other studies find mixed or insignificant results (e.g. Rockenbach et al., 2007; Baker et al., 2008) or results that depend on the type of risk (e.g. Shupp and Williams, 2008). Comparing risk attitudes about own payoff vs. the payoff of *one* other person, again evidence is mixed (e.g. Pahlke et al., 2015; Agranov et al., 2014; Eckel and Grossman, 2008b; Chakravarty et al., 2011; Faro and Rottenstreich, 2006).

[2]Overall, their findings suggest a deterring impact of own and other's risk on prosocial

et al. (2005, 2007) and Sleesman and Conlon (2016) discuss the importance of revealing information about the charity's quality, i.e. about its ability to convert donations into impact. Note that, in contrast to non-strategic dictator game types of situations, in public good games, a player benefits from her own and others' investments and at the same time a player's investment benefits herself and others. These interdependencies introduce different questions for how risk may impact individual (pro-social) behavior compared to non-strategic giving scenarios. An early study by Dickinson (1998) shows reduced giving when returns from the public good become risky. Similarly, Levati et al. (2009), Levati and Morone (2013), Stoddard (2015), Björk et al. (2016) and Théroude and Zylbersztejn (2017) consider voluntary contributions with risky returns. In these studies, benefits from the public good accrue to all subjects. Differently, Brennan et al. (2008) consider an asymmetric setting in a 2-player game and introduce risk in the return from the public good only for one contributor.

Perhaps closest to our study, Gangadharan and Nemes (2009) and Stoddard (2017) conduct a lab experiment in which either the return from the public good is risky for all group members or the return from the subject's private account is risky but the return from the public account is not. Our experiment differs from Gangadharan and Nemes (2009) by always keeping safe the non-invested amount, i.e. the private account, while introducing risks in the private and public components of the *return* from investment. Our setting thereby allows for a comprehensive investigation into how investment decisions depend on the presence of the respective risks as well as their interactions. Additionally, our design enables us to identify and decompose reasons *why* individual contributions to public goods with risky returns are typically lower than they are under certainty, as has been observed in the above studies.

The remaining paper is structured as follows: in section 2.1 we introduce the experimental treatments. Predictions are derived in section 2.3, the experimental procedure reported in 2.2. Results are presented in section 3,

behavior, although the evidence especially concerning risk for the other person is mixed. This effect appears to depend on which possible motivations drive behavior in the specific experimental design. Those include for example the distinction between concerns for ex ante vs. ex post payoff comparisons (Krawczyk and Le Lec, 2010; Brock et al., 2013) or self-deceptive behavior (Dana et al., 2007; Andreoni and Bernheim, 2009; Exley, 2014).

before we conclude in section 4.

2 Experimental Design

2.1 Treatments

In order to investigate how risk in private returns and social returns, i.e. returns to other players, impacts investment decisions, we consider several treatments that vary in how they introduce risk into a variant of a standard public good game. In groups of four players, subjects make symmetric and simultaneous decisions on how much of their private endowment to invest in a public account. Individuals' investments may generate both a private return to the player herself, as well as a return to other group members. That is, while in the typical public good game private (marginal) returns coincide with the (marginal) returns to others, we separate these two dimensions. The design relates to Goeree et al. (2002) but additionally introduces risk in the respective dimensions.[3] This manipulation allows us to isolate the impact of risk in private and public returns.

Specifically, we assume the following state-dependent payoff of an individual i within four-player variants of the public good game:

$$\pi_i(s_r, s_h) = m - x_i + r(s_r)x_i + h(s_h)\sum_{j \neq i} x_j \tag{1}$$

Here, m is the initial endowment and x_i denotes the investment by individual i. s_r and s_h reflect the states of nature that determine the private and public return, respectively. [4] The private rate of return from individual investments is referred to as $r(s_r)$, while $h(s_h)$ denotes the rate of return from the other three group members' investments. Conversely, player i's investment x_i also generates payoff chances for the other players. The expected returns are

[3]Goeree et al. (2002) employ this mechanism to disentangle altruistic motivation from noisy behavior in a public good game. They call the two returns from an individual's contribution an "internal return" for oneself and an "external return" from/to the other group members.

[4]The private return bears similarity to the functioning of a rebate in the charitable giving literature (e.g., Eckel and Grossman, 2006; Karlan and List, 2006). This literature does not consider risk.

denoted by $\bar{r} := \mathbb{E}[r(s_r)]$ and $\bar{h} := \mathbb{E}[h(s_r)]$. To satisfy the social dilemma, we assume that $\bar{r} < 1$, $\bar{r} + (n-1)\bar{h} > 1$: while it is socially desirable in expected payoff terms to invest the full endowment, this does not pay out at the individual level. For the experiment we use $\bar{h} = \bar{r} = 0.5$.

Our baseline treatment *NoRisk* is payoff-equivalent to the standard public good game with a MPCR of 0.5: each token invested by a player generates half a token to the player herself ($r = \bar{r} = 0.5$) as well as to each of the other players ($h = \bar{h} = 0.5$). With 4 players, an individual contribution to the public good is thus multiplied by 2 before being distributed among all group members. All other treatments implement identical expected returns in both dimensions, but introduce risk in the public or the private return or in both.

For this, we allow for two different states $s_r, s_h \in \{0, 1\}$ and denote

$$r(s_r) = \begin{cases} r^H & \text{if} \quad s_r = 1 \\ r^L & \text{if} \quad s_r = 0 \end{cases} \qquad\qquad h(s_h) = \begin{cases} h^H & \text{if} \quad s_h = 1 \\ h^L & \text{if} \quad s_h = 0 \end{cases}$$

with $h^H > h^L$ and $r^H > r^L$. Again, we keep a symmetric structure in the experiment when choosing the parameters

$$r^H = h^H = 1 \qquad r^L = h^L = 0$$

and we assume that the states are equally likely, i.e. high or low returns result with a probability of 50%. In the main treatments, the random draws are executed at the group level, i.e. either all or none of the players of a group get a return in the respective dimension. This prevents concerns about ex-post inequality in the returns from the public good to influence contribution decisions.

With simultaneous risks in both dimensions, the overall riskiness of the investment and the effect on the investor's decision depend on the *interaction* of the two risks. Therefore, we have to distinguish three possible cases of how the two random draws are related: the risks can be independent (*BothRisks$_{Ind}$*), (perfectly) negatively correlated (*BothRisks$_{Neg}$*), or (perfectly) positively correlated (*BothRisks$_{Pos}$*). Treatment *BothRisks$_{Pos}$* is equivalent to a public good game with risky MPCR: own and public return

Treatment	Private Return	Public Return
NoRisk	$\bar{r}$	$\bar{h}$
BothRisks (Ind,Pos,Neg)	r^H or r^L	h^H or h^L
PrivateRisk	r^H or r^L	$\bar{h}$
PublicRisk	$\bar{r}$	h^H or h^L

Table 1: Treatment Structure

are identical and coincide for all subjects. Given our parameter choice of $r^L = h^L = 0$, we can interpret this situation as the public good *not* being provided with a probability of 50%. $BothRisks_{Neg}$ resembles a situation where subjects pledge to invest a particular amount for an envisioned project. If the project materializes (with 50% chance), payments are enforced ($r^L = 0$) and a public return is generated ($h^H = 1$). If the project does not materialize, no public return results ($h^L = 0$), but the pledged amount is fully returned to the investor ($r^H = 1$). In addition, in $BothRisks_{Ind}$ we consider the case where both private and public returns are independent, simplifying a situation where the underlying factors that determine whether the investment is successful are independent for the private and the public return. As an example, a private return might not depend on the realization of a public benefit like an environmental impact.

We further use the decomposed returns to isolate the extent to which risk in either return impacts investment decisions, i.e. we consider treatments *PrivateRisk* with risk *only* in the private return ($r^L = 0, r^H = 1, h = 0.5$), and *PublicRisk* with risk *only* in the public dimension ($r = 0.5, h^L = 0, h^H = 1$). We again chose to implement the random draws at the group level to capture a situation where the public project either fails or is successful, in which case it generates returns to all players. While this appears a reasonable feature for real-life investments, it comes at a cost in our symmetric four-player public good game environment: when investments by player i result in successful giving to others, the investments of the other three players also generate a return to i. Thus, own final income of a player and the return of her own investment to others are positively correlated. As a robustness check, a final treatment $PublicRisk_{Ind.Level}$ implements independent individual random draws for each group member. By independently determining the return from the investment by each player, this treatment controls for (expected) wealth effects by breaking the positive correlation between own income and the success of own giving decisions.

2.2 Procedure

The experiment consists of two parts, a repeated public good game in the variants described in section 2.1 in Part 1 and two risk preference elicitation tasks in Part 2.

Part 1 In Part 1, participants make investment decisions over ten periods in a partner matching under one of the treatment conditions (between-subjects design). Each group consists of four players. In each round, a player receives an endowment of 100 Tokens in her private account, called "*Account A*", and decides how many of these to "*transfer*" into another account, "*Account B*". Account B then determines the returns to herself and the other group members. At the end of each round, feedback on the aggregate decisions by the other players in a subject's group is given, whereas random draws on the returns from investments are only drawn after all decisions have been made.[5] One round is randomly chosen for payment. Before the beginning of the experiment, subjects are asked to answer a set of control questions covering several possible situations in the experiment and, in order to create common knowledge of participants' understanding, they are only allowed to proceed after having answered all questions correctly.

Part 2 In Part 2, we use the simple risk elicitation task by Eckel and Grossman (2008a) and Dave et al. (2010) in which subjects choose one of six lotteries, summarized in the "outcome" columns of Table 2. All lotteries give payoffs A or B with a probability of 50% each. The last two columns of Table 2 were not shown to subjects but show that expected value and

[5]By letting subjects play the game over ten periods, we allow for behavior to converge towards some equilibrium (e.g., if players show reciprocal behavior) and expect a typical downward trend of public good contributions. Informing players only about others' contributions prevents creating noise through different realizations of the random draws on the return from investments in each group in each round. Such noisy payoffs have been shown to possibly affect subjects' strategic learning (Bereby-Meyer and Roth, 2006, e.g.), which we want to exclude as a possible explanation for treatment differences to *NoRisk*.

	Outcomes			
	A	B	EV	SD
1	56	56	56	0
2	48	72	60	12
3	40	88	64	24
4	32	104	68	36
5	24	120	72	48
6	4	140	72	68

Table 2: Lottery list in part 2. Each row is one lottery with equally likely outcomes A and B. EV denotes expected value and SD the standard deviation of the respective lottery, both were not shown to participants.

standard deviation of the lotteries increase from the top to the bottom. A very risk-averse individual should thus choose lottery 1, a risk-neutral person is predicted to choose lottery 5 or 6 with the highest expected value, and risk-seeking subjects may choose lottery 6. Participants are asked to make this choice twice in random order: one decision only matters for their own payoff (choice L_{own}) and the other decision determines the lottery affecting the payoff of all members of their group (choice L_{group}). After all choices have been made, a random draw on the group level determines which of the two choices is relevant for payment.[6] For our discussion of results, we use the lottery choices for own payoff to classify subjects who choose 1 through 4 ($L_{own} \leq 4$) as risk-averse (RA) and those who choose 5 or 6 ($L_{own} \geq 5$) as non-risk-averse (NRA).

Implementation The experiment was conducted in the experimental laboratory of the Faculty of Business, Economics and Social Sciences, University of Hamburg, Germany, in 2015. We conducted 14 sessions with students from all departments of the University of Hamburg. The total number of participants is 336 with 48 subjects per treatment (24 per session). The experiment is implemented using ztree (Fischbacher, 2007). Tokens are converted into Euro at an exchange rate of 100 Tokens=5€. Total payoffs consist of a show-up fee (5€) plus the payoff from Part 1 plus the payoff from Part 2. Total average earnings are 15.63€. An English translation of the experimental

[6]In case the group choice is drawn, the choice of a randomly selected group member is implemented for the whole group.

instructions, originally in German, can be found in Appendix C.

2.3 Predictions

There is overwhelming evidence that individuals in public good games give positive amounts (e.g., Zelmer, 2003). This can be attributed to a combination of behavioral motivations like conditional cooperation (Chaudhuri, 2011) together with efficiency concerns or kindness (e.g., Rabin, 1993). These concerns essentially mean that a (conditional) cooperator cares not only about the impact of his actions on his own payoff, but also about the impact on the payoffs of others. The weight put on giving to others might depend on the observed behavior of others ($x_j, j \neq i$) and the kindness she infers from their level of contributions.[7] In Appendix B we provide a simple model capturing these ideas. The model additionally allows for diverse risk attitudes with respect to own payoff as well as to giving to others. Here, we will briefly discuss the reasoning for the treatment differences we expect to observe.

NoRisk ($r(s_r) = h(s_{h,i}) = 0.5$) provides identical incentives as a standard public good game with a homogeneous marginal return of 0.5. We to observe similar behavior as found in the literature as we do not expect contribution decisions to be impacted by the different framing that separates own and others' returns. In $BothRisk_{Neg}$, investments do not lead to a change in income ($1 - r(s_r) = h(s_{h,i}) = 0$) with 50% chance, or alternatively result in a marginal effect on own and others' payoffs ($1 - r(s_r) = h(s_{h,i}) = 1$) that is twice as large as under *NoRisk*. To put it differently, in 50% of the cases, subjects end up with their initial endowment independent of theit decisions. With 50% chance, though, all payoffs are identical to those in the *NoRisk* treatment if the investments are half the ones chosen in *NoRisk*. Without changes in the perceived kindness, we would thus expect investments in $BothRisk_{Neg}$ to be half of those in *NoRisk*. If these reduced investments are perceived as less kind, individual contributions would be even smaller.

[7] People may also directly receive utility from giving to others. Altruistic preferences are seen as increasing in the monetary payoff to other subjects (Palfrey and Prisbre, 1997; Ledyard, 1995), with evidence gathered by, e.g., Anderson et al. (2011) and Goeree et al. (2002). Differently, warm-glow preferences sometimes refer to a situation where subjects get utility from the intention of contributing (Palfrey and Prisbre, 1997; Andreoni, 1989), not necessarily considering the success of giving.

While expected values are kept constant, risk attitudes can be expected to affect giving across treatments: risk-aversion (compared to risk-neutrality) with respect to own payoff should lower investments if private returns are risky in *PrivateRisk* and $BothRisk_{Pos}$ compared to investments under certainty. In fact, we can predict that risk-aversion w.r.t. own payoff leads to larger transfers in $BothRisk_{Neg}$ than in $BothRisk_{Ind}$, and larger still than in $BothRisk_{Pos}$. This demonstrates the importance of how risk in public returns interacts with existing private risk. Also, risk-aversion with respect to own payoffs should diminish investments in the latter two treatments compared to a situation where only *PublicRisk* is present. On the other hand, risk-aversion over others' payoffs should lower giving when public risk exists compared to *NoRisk* and *PrivateRisk*. Overall, treatment differences as well as individual behavior can be expected to crucially depend on individuals' risk attitudes. Because predictions essentially rely on people's risk preferences in the respective domain, it is crucial to allow for risk attitudes over own and others' payoffs to differ in our model (Appendix B) and to empirically elicit both measures for interpreting treatment differences.

3 Results

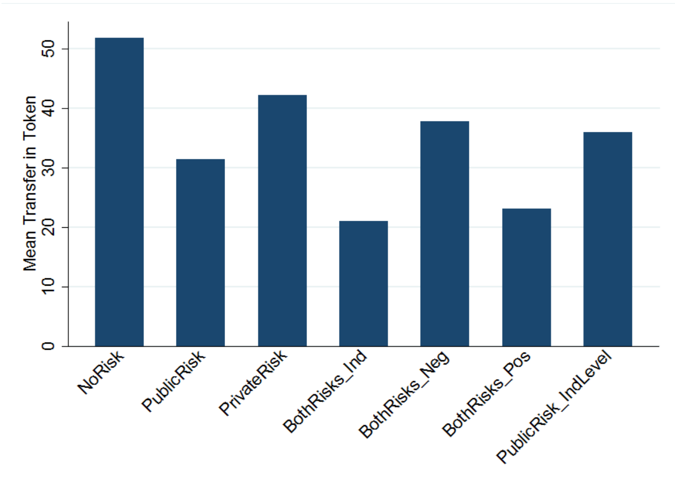

Figure 1: Mean transfers in each treatment (all periods)

Treatment Differences in Contributions. Investments are highest in the baseline treatment *NoRisk* (51.77 out of 100 tokens). The lowest average investments result if both own return and others' return are risky and positively correlated ($BothRisks_{Pos}$, 23.06 tokens) or independently drawn ($BothRisks_{Ind}$, 21.10 tokens). For both treatments, differences to *NoRisk* are significant ($p < 0.05$, Mann-Whitney U test of the equality of distributions (MWU) and two-sample bootstrapped t-test (2-sided, BTT), comparing group averages across all periods).[8][9] Detailed summary statistics for decisions in all treatments are given in Table 5.[10] The means across all periods are also reported in Figure 1.

Result 1 *Relative to non-risky returns, average investments are significantly lower when both private and public returns are risky and positively correlated or independently drawn.*

The reduced investments when private and public returns are risky and positively correlated correspond to earlier findings in the literature that risky returns may reduce giving in standard public good games (e.g., Dickinson, 1998; Gangadharan and Nemes, 2009). A similar level of investments as in the positively correlated risk treatment results if private and public returns are drawn independently. One reason for this, that goes beyond our predictions, might be that the worst case in both treatments lets individuals obtain neither any private nor any public return, i.e. a return of zero.[11] In line with this interpretation, investments in $BothRisk_{Neg}$ are significantly larger (37.79) than in the case of positively or independently correlated risks ($p < 0.05$ (MWU)).[12] Here, the negative correlation of public and private returns essentially attenuates the downside risk and might provide an in-

[8] As a conservative measure, we discuss treatment differences while taking group means across all periods as one independent observation. The results are robust to using decisions in the first period which allows to take one decision per individual as an independent observation.

[9] Throughout this section, we report p-values from both tests. We chose to report p-values from bootstrapped t-tests in addition to the non-parametric MWU tests, because the latter does not take the cardinal information in the data into account.

[10] We report average decisions across all 10 periods as well as for the first period, periods 1 through 5, and periods 6 through 10. We further provide mean decisions separated by risk type. Following the neutral wording in the experimental instructions, the tables report the "transfer" decisions instead of "investments".

[11] However, we do not see any explanatory power in our measures of risk-aversion to explain these treatment differences.

[12] The difference to $BothRisk_{Pos}$ is not significant with a bootstrapped ttest.

surance effect. Following our prediction, we compare total investments in $BothRisk_{Neg}$, where decisions correspond to a pledge to give, with half the amount in *NoRisk*. We find that investments tend to be larger than expected under negatively correlated risk (37.79 vs. 0.5*51.77, $p = 0.11$ MWU, BTT).

When introducing either only private risk (*PrivateRisk*) or only public risk (*PublicRisk* and $PublicRisk_{Ind.Level}$), investments tend to decrease relative to *NoRisk*, even though the differences are not statistically significant when averaging across all agents and all periods. However, considering only first period decisions—which allows for taking individual decisions as independent observations—investments are (weakly) significantly smaller under private risk ($p < 0.1$) and under both public risk conditions ($p < 0.01$, MWU, BTT) than under *NoRisk*.

For the introduction of public risk, the two public risk conditions with random draws on the group or on the individual level do not differ significantly, indicating that it is not important if *all* subjects' giving has identical success. $PublicRisk_{Ind.Level}$ reduces the riskiness of own wealth relative to *PublicRisk* as the success of giving by the three other players is independently determined. The minor increase in tokens contributed in the former indicates that income risk from investments by others does not severely affect own decisions in our setting. It also indicates that expected ex-post inequalities *in payoffs from the public good* are not a strong driver of investment decisions under uncertainty (there may be inequality in final outcomes).[13]

Notably, adding positively correlated or independent public risk further reduces investments relative to a situation in which only private returns are risky ($PrivateRisk > BothRisk_{Pos}, BothRisk_{Ind}$, $p < 0.05$ (MWU, BTT)[14]), while investments under negatively correlated risk are almost indistinguishable from *PrivateRisk* only. At the same time, relative to a situation where

[13]The comparison between these two treatments resonates with Fischbacher et al. (2014) and Théroude and Zylbersztejn (2017) who introduce asymmetries between contributors. In line with our finding, Théroude and Zylbersztejn (2017) do not observe significant changes in behavior when random draws are made at the group level or at the individual level. However, in contrast to our finding (and much of the literature) they do not find a significant difference between the introduction of risk in the returns from the public good compared to a VCM under certainty. Fischbacher et al. (2014) also find that introducing heterogeneity in MPCRs does not significantly alter average contributions in a one-shot linear public good game without uncertainty, compared to a situation with the same MPCR for all.

[14]The difference between *PrivateRisk* and $BothRisk_{Pos}$ is only significant with MWU.

only public returns are risky, adding private risk does not lead to statistically significant changes.

Result 2 *Adding independent or positively correlated public risk to already existing private risk (further) reduces investments, while additional negatively correlated public risk does not change investments compared to a situation with only private risk.*

For a parametric test of treatment differences in average behavior, we estimate (individual) random effects models with standard errors clustered at the group level.[15] Additionally, we report results from random effect probit models to show what drives subjects to give positive amounts. In both models, treatments are defined as binary variables equal to one if the respective treatment condition applies. *NoRisk* serves as the baseline. The regressions confirm the treatment effects we have identified above. Table 6, column (1) shows that risk in each dimension, but particularly public risk, reduces investments. Similar results are obtained for the participation decision (column (3) and (4) of Table 6): relative to *NoRisk*, risky public returns in *PublicRisk*, $BothRisk_{Ind}$ and $BothRisk_{Pos}$ reduce the share of subjects investing a positive amount.

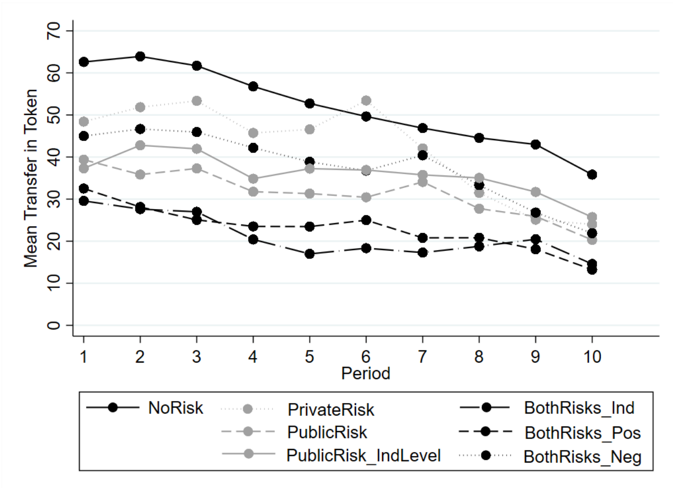

Figure 2: Transfers over all periods

[15] With 84 groups, the number of clusters is large enough to obtain reliable estimates. The results are robust when running tobit models instead.

Treatment Differences Over Time. Over the course of all ten periods, average investments exhibit a downward trend in all treatments (see Figure 2). However, the negative impact of independent or positively correlated public risk on investments relative to private risk (and relative to no risk) remains stable when only considering decisions in the last five periods. In the presence of risky private returns, additional risk on the impact of giving thus crucially impacts investment decisions even after several periods of interactions. To confirm these observations, Table 7 reports the same regressions as in Table 6 for decisions in period 6-10 only. While the treatment differences are smaller in later periods, the overall pattern of treatment effects remains, except for the effect of *PublicRisk* which, while it is still large in magnitude, is no longer statistically significant.

Heterogeneity in Treatment Differences. To identify risk types, we begin by reviewing the two lottery choices in Part 2 of the experiment. Both choices over lotteries, reported in Table 3, show on average moderate risk aversion. We code 203 subjects as risk-averse (RA) and the remaining 133 as non-risk-averse (NRA). We use this classification to study the role of risk attitudes for investment decisions in the respective treatments.[16] While the lottery choices over own and group payoffs are significantly correlated, 54% of the participants switched between the two choices (see Table 4).[17]

Following our predictions, we allow for interactions between treatments and risk attitudes in the random effects models in Table 6 to gain more detailed insights into how risk attitudes affect investment decisions. Risk attitudes

[16]As we were primarily interested in the investment behavior, we decided to conduct the risk-elicitation task in Part 2. While mean lottery choices vary slightly between treatment groups, this variation appears unsystematic and is unrelated to the degree of riskiness of the public good that participants were exposed to in Part 1.

[17]In line with much of the literature (e.g., Harrison et al., 2013), we do not observe a significant difference in average risk attitudes of subjects when acting on behalf of their group vs. only for themselves. Our predictions suggest to additionally separate risk attitudes w.r.t. own payoff vs. the payoff of others. In L_{group}, both those attitudes are mixed. However, subjects who act *more* risk-averse when deciding for the group than for their own payoff, can be identified as risk-averse w.r.t. the payoff of others. We therefore use the *difference* between the decisions in L_{own} and L_{group} to classify subjects as risk-averse w.r.t. other's payoff (RAother if $L_{group} < L_{own}$) or as non-risk-averse w.r.t. others' payoff (NRAother if $L_{group} \geq L_{own}$). Thus, 94 subjects are coded as RAother, while the remaining 242 are coded as NRAother. However, an additional inclusion of these variables in our analysis cannot explain decisions such that our analysis below concentrates on risk attitudes w.r.t. own payoff, i.e. on RA vs. NRA.

are coded as binary variables as described above. Separating by risk types, we see in column (2) that the effects are mainly driven by risk-averse subjects, while the treatment differences appear smaller for non-risk-averse subjects. While most interactions are not statistically significant but point in the same direction, the treatment differences in $BothRisks_{Neg}$ and *PrivateRisk* appear to be driven entirely by RA players, while no treatment differences result for non-risk-averse subjects (column (2)).[18] The differences in participation decision (column (3) and (4) of Table 6) across treatments are robust for both NRA and RA types.

4 Conclusions

We found evidence that the riskiness of both private and public returns matters for investment decisions. Based on variants of public good games which allow us to disentangle the risk of investments in *own* vs. *others'* returns, we find that the correlation between both risks matters when risks are present in both dimensions: if both risks are positively correlated or independent, investments are substantially impacted, compared to a situation where only private returns are risky or no risks exist. The similarity of investments under both positively correlated and independent risk treatments suggests that people might not consider the whole distribution of risks, but instead focus on the downside risk of ending up with zero returns in both dimensions.

We therefore can conclude that a reduction in risk in the success of giving to others, i.e. the return of the investment to others, is crucial to stabilize investments when a public component is present. This holds true in the absence as well as in the presence of private risk. With this, our findings further support models that assume utility being driven by the *success* in giving, rather than by the *act* of giving up own payoff alone, thereby extending evidence gathered by, e.g., Anderson et al. (2011), Goeree et al. (2002) and Palfrey and Prisbre (1997) to risky situations.

In our experiment we chose a rather extreme distribution of possible returns, i.e. returns of 0 and 1, which facilitated the derivation of predictions

[18] The negative coefficient of NRA (though not significant) indicates that risk-aversion may be positively correlated with investments in the *NoRisk* treatment, in line with results by Freundt and Lange (2017) for giving in dictator games.

(see Appendix B) and greatly simplified participants' decisions in the lab. It remains to be seen in future research how robust the findings are to less extreme returns, particularly when a positive return is secured in any state of the world. However, we consider our setting to be informative of many applications: microlending, crowdinvesting, charitable donations, and environmental protection (e.g., abatement of emissions) may all come with a risk of complete failure to provide a promised public return. Our experiment indicates that reducing the risk in such situations may be crucial to attracting investments.

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Appendix A: Figures and Tables

	1	2	3	4	5	6	Mean
L_{own}	37	32	66	68	69	64	3.87
L_{group}	34	40	39	88	66	69	3.95

Table 3: Lottery choices in risk tasks for own and group payoff

	L_{own}						
	1	2	3	4	5	6	all
$L_{own} < L_{group}$	26	15	36	11	6		94
$L_{own} = L_{group}$	11	13	16	38	45	45	168
$L_{own} > L_{group}$		4	14	19	18	19	74

Table 4: Changes in choices for lottery for own vs. group payoff

Periods		all	1	1-5	6-10	all	all
Participants		all	all	all	all	RA	NRA
NoRisk	x	51.77	62.60	59.55	43.98	55.49	44.31
		(41.59)	(37.85)	(39.59)	(42.18)	(40.35)	(43.15)
	n	480	48	240	240	320	160
$BothRisks_{Ind}$	x	21.10	29.58	24.32	17.89	19.26	23.92
		(27.92)	(27.65)	(28.83)	(26.66)	(23.49)	(33.45)
	n	480	48	240	240	290	190
$BothRisks_{Pos}$	x	23.06	32.52	26.54	19.59	21.93	24.53
		(30.06)	(33.32)	(30.84)	(28.91)	(27.04)	(33.56)
	n	480	48	240	240	270	210
$BothRisks_{Neg}$	x	37.79	45.00	43.73	31.85	33.74	46.71
		(33.66)	(34.56)	(33.80)	(32.52)	(29.81)	(39.55)
	n	480	48	240	240	330	150
PrivateRisk	x	42.20	48.42	49.18	35.22	37.67	46.37
		(38.01)	(36.26)	(36.37)	(38.40)	(32.63)	(41.99)
	n	480	48	240	240	230	250
PublicRisk	x	31.40	39.38	35.12	27.69	30.96	31.93
		(34.54)	(36.11)	(34.46)	(34.28)	(33.98)	(35.25)
	n	480	48	240	240	260	220
$PublicRisk_{Ind.Level}$	x	35.93	37.31	38.83	33.03	35.75	36.34
		(33.58)	(31.86)	(33.62)	(33.37)	(32.99)	(34.96)
	n	480	48	240	240	330	150

Table 5: Summary statistics of transfers. (x = mean number of Taler transfered (with std. dev.), n = number of subjects)

Dep.Var.	(1) Transfer	(2) Transfer	(3) Participation	(4) Participation
$BothRisks_{Ind}$	-30.66***	-36.24***	-1.17***	-1.09**
	(-3.11)	(-3.41)	(-3.20)	(-2.37)
$BothRisks_{Pos}$	-28.70***	-33.57***	-0.90**	-0.82*
	(-2.65)	(-3.11)	(-2.45)	(-1.74)
$BothRisks_{Neg}$	-13.98	-21.76**	-0.23	-0.18
	(-1.36)	(-2.06)	(-0.63)	(-0.41)
$PrivateRisk$	-9.56	-17.82	-0.48	-0.51
	(-0.89)	(-1.53)	(-1.31)	(-1.05)
$PublicRisk$	-20.36**	-24.53**	-0.69*	-0.78*
	(-2.00)	(-2.15)	(-1.90)	(-1.65)
$PublicRisk_{IndLevel}$	-15.83	-19.75*	-0.43	-0.49
	(-1.47)	(-1.71)	(-1.16)	(-1.08)
NRA		-11.18		-0.39
		(-1.31)		(-0.71)
NRA x $BothRisks_{Ind}$		15.85		-0.15
		(1.57)		(-0.19)
NRA x $BothRisks_{Pos}$		13.78		-0.08
		(1.34)		(-0.11)
NRA x $BothRisks_{Neg}$		24.16**		-0.16
		(2.02)		(-0.20)
NRA x $PrivateRisk$		19.88*		0.19
		(1.70)		(0.26)
NRA x $PublicRisk$		12.15		0.29
		(1.12)		(0.39)
NRA x $PublicRisk_{IndLevel}$		11.77		0.12
		(0.95)		(0.16)
Constant	51.77***	55.49***	1.42***	1.56***
	(5.84)	(5.78)	(5.33)	(4.73)
Observations	3,360	3,360	3,360	3,360

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Random effect models on transfers x_i across all periods (column (1) and (2)). Random effects probit on participation ($x_i > 0$) across all periods (column (3) and (4)).

Dep. Var.	(1) Transfer	(2) Transfer	(3) Participation	(4) Participation
$BothRisks_{Ind}$	-26.10**	-31.22**	-1.21***	-1.20**
	(-2.34)	(-2.53)	(-2.89)	(-2.30)
$BothRisks_{Pos}$	-24.40**	-29.71**	-0.75*	-0.76
	(-2.09)	(-2.41)	(-1.84)	(-1.45)
$BothRisks_{Neg}$	-12.13	-19.30	-0.18	-0.15
	(-1.05)	(-1.56)	(-0.44)	(-0.29)
$PrivateRisk$	-8.76	-15.25	-0.51	-0.52
	(-0.73)	(-1.17)	(-1.25)	(-0.96)
$PublicRisk$	-16.29	-20.80	-0.63	-0.77
	(-1.41)	(-1.63)	(-1.53)	(-1.45)
$PublicRisk_{IndLevel}$	-10.95	-17.03	-0.10	-0.25
	(-0.94)	(-1.35)	(-0.24)	(-0.49)
NRA		-14.64*		-0.62
		(-1.96)		(-1.02)
NRA x $BothRisks_{Ind}$		15.26		0.07
		(1.64)		(0.08)
NRA x $BothRisks_{Pos}$		15.62*		0.16
		(1.71)		(0.20)
NRA x $BothRisks_{Neg}$		21.97*		-0.13
		(1.90)		(-0.15)
NRA x $PrivateRisk$		17.73		0.23
		(1.50)		(0.28)
NRA x $PublicRisk$		13.83		0.47
		(1.31)		(0.56)
NRA x $PublicRisk_{IndLevel}$		18.47*		0.37
		(1.68)		(0.42)
Constant	43.98***	48.86***	1.06***	1.28***
	(4.35)	(4.40)	(3.56)	(3.46)
Observations	1,680	1,680	1,680	1,680
Number of subjects	336	336	336	336

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Random effect models on transfers x_i across periods 6-10 (column (1) and (2)). Random effects probit on participation ($x_i > 0$) across periods 6-10 (column (3) and (4)).

Appendix B: Illustrating theoretical model

To guide our intuition on the behavior in our treatments, we formulate a simple model on conditional cooperation:

$$\mathbb{E}[U_i] = \mathbb{E}\left[u_i(m - x_i + r(s_r)x_i + \sum_j h(s_{h,j})x_j) + \kappa_i(\sum_{j\neq i} x_j)v_i(h(s_{h,i})x_i)\right].$$

A subject i's utility depends on her own payoff $m - x_i + r(s_r)x_i + \sum_j h(s_{h,j})x_j$ and additionally on her impact on the payoff of others $(h(s_{h,i})x_i$, e.g. through a warm-glow-sensation. For both utility components we allow for diverse risk attitudes, captured by u_i and v_i, respectively. Conditional cooperation motives are captured by κ_i which we assume to be increasing in the investments of others, i.e. in their intention to give to i.

The first order condition is given by

$$\mathbb{E}\left[-u_i'(\cdot)(1 - r(s_r)) + \kappa_i(\cdot)v_i'(\cdot)h(s_{h,i})\right] \leq 0 \qquad (2)$$

with equality for an interior solution where we assume that subjects do not invest all their income.

Given our parameter settings, the first-order condition reduces to simple expressions for the respective treatments:

$$\begin{aligned}
&\textit{NoRisk} && -0.5u_i'(m - x_i + 0.5x_i + 0.5\sum_{j\neq i} x_j) + 0.5\kappa_i(\cdot)v_i'(0.5x_i) \leq 0 \\
&\textit{BothRisk}_{Pos} && -0.5u_i'(m - x_i) + 0.5\kappa_i(\cdot)v_i'(x_i) \leq 0 \\
&\textit{BothRisk}_{Neg} && -0.5u_i'(m - x_i + \sum_{j\neq i} x_j) + 0.5\kappa_i(\cdot)v_i'(x_i) \leq 0 \\
&\textit{BothRisk}_{Ind} && -0.25u_i'(m - x_i) - 0.25u_i'(m - x_i + \sum_{j\neq i} x_j) + 0.5\kappa_i(\cdot)v_i'(x_i) \leq 0 \\
&\textit{PrivateRisk} && -0.5u_i'(m - x_i + 0.5\sum_{j\neq i} x_j) + 0.5\kappa_i(\cdot)v_i'(0.5x_i) \leq 0 \\
&\textit{PublicRisk} && -0.25u_i'(m - x_i + 0.5x_i + \sum_{j\neq i} x_j) \\
& && -0.25u_i'(m - x_i + 0.5x_i) + 0.5\kappa_i(\cdot)v_i'(x_i) \leq 0
\end{aligned}$$

The second order conditions are automatically satisfied. The first order-conditions allow to make predictions on the treatment differences in the investment by player i, conditional on the decisions of other players $j \neq i$.

We obtain the following predictions:

Predictions

(i) Independent of the level of risk-aversion, all subjects are predicted to give at most half the amount in $BothRisk_{Neg}$ than in NoRisk.

(ii) Risk-aversion w.r.t. own payoff reduces investments in PrivateRisk and in $BothRisk_{Pos}$ relative to NoRisk.

(iii) Risk-aversion w.r.t. the public return reduces investments in all treatments involving public risk relative to PrivateRisk and NoRisk.

(iv) Comparing PublicRisk with NoRisk, risk-aversion w.r.t. own payoff depends on u'''. For prudent decision makers ($u''' > 0$), investments are reduced under public risk.

(v) Risk-aversion with respect to own payoff reduces investments in $BothRisk_{Pos}$ and $BothRisk_{Ind}$ relative to PublicRisk. The comparison of $BothRisk_{Neg}$ with PublicRisk depends on giving by others: giving in $BothRisk_{Neg}$ is smaller if $\sum_{j \neq i} x_j$ is small, but is larger if $\sum_{j \neq i} x_j \geq 0.5 x_i$, i.e. in any symmetric equilibrium.

(vi) Risk-aversion w.r.t. own payoff leads to larger investments in $BothRisk_{Neg}$ than in $BothRisk_{Ind}$ than in $BothRisk_{Pos}$.

Proof:

(i) In $BothRisk_{Neg}$, it is easily seen that – for fixed κ_i – the first order condition holds if investments are exactly half the ones that solve the conditions in *NoRisk*. If these reduced investments are perceived as less kind and reduce κ_i, we would predict that investments in $BothRisk_{Neg}$ are less than half of those in *NoRisk*.

(ii) Follows from $u_i'(m - x_i) \geq u_i'(m - x_i + 0.5 x_i) \geq u_i'(m - x_i + 0.5 x_i + \sum_{j \neq i} x_j)$.

(iii) Follows from $v'(0.5x_i) > v'(x_i)$ under risk-aversion ($v'' \leq 0$).

(iv) For $u''' > 0$, $0.25u_i'(m - x_i + 0.5x_i + \sum_j x_j) + 0.25u_i'(m - x_i + 0.5x_i) < 0.5u_i'(m - x_i + 0.5x_i + 0.5\sum_{j \neq i} x_j)$ which does not necessarily hold in general.

(v) Reasoning identical to (ii) as the marginal utility from giving does not change.

(vi) Reasoning identical to (ii). □

Appendix C: Experimental instructions

Below we report an English translation of the instructions for treatment BothRisks$_{Pos}$. The original instructions have been in German. The parts that might differ according to the treatment condition are marked in italic.

Welcome to the Experimental laboratory and thank you for participating in this economic experiment.

Please switch off your phones during the entire experiment. Communication with other participants is not allowed and a violation of this rule will lead to an exclusion from the experiment as well as from all payments. If you have any questions during the experiment, please raise your hand, we will come to you.

Procedure

The experiment consists of two entirely independent parts. The instructions for the second part will be distributed and read out to you after the first part is over. The decisions you make in the first part are **not** relevant for the payoffs in the second part and the other way round. In the end, the earnings from part 1 and from part 2 will both be paid out to you.

Part 1

Payoffs

In part 1 you will make several decisions that determine your income as well as the income of other participants. The actual payoffs will partly depend on chance. As your decisions will determine the size of your earnings, it is important that you read the instructions carefully before making any decisions. If something is unclear to you, please do not hesitate to ask!
Your income in the experiment will be calculated in Taler. Taler will be converted into Euro with an exchange rate of

100 Taler=5 Euro.

Your total payoff consists of the sum of the payoffs from part 1 and part 2. In addition, you receive a show-up fee of 5 Euro for participating in the experiment. You will be paid out in cash immediately after the experiment is over. The other participants will not be able to see how much money you receive.

Procedure

All decisions will be **anonymous**, i.e. neither another participant nor the experimenter can match them to your identity.
The experiment consists of **10 rounds** in which you will be in the same decision situation. Before the beginning of the first round, you will be connected with three other participants that are chosen randomly into a group consisting of 4 people in total. None of the participants knows with whom they are matched into a group. During the entire experiment, i.e. in all 10 rounds, you stay in one group with the same participants. In each round all participants make the same decision. After the 10 rounds are over, you will see an information screen with the payoffs for each round. Out of the 10 rounds, one round will determine your payoff. Each round can be drawn with the same probability. This round will be determined by a random draw, for which one participants in the room will be chosen to draw one out of 10 cards with the numbers 1 to 10. Only the round that is drawn here will be paid out in the end.

Decision Situation

Before every decision, a brief description of the respective decision situation will appear on your screen. In case you have any questions, please raise your hand, we will come to you!
For each decision you make, you will be provided with **100 Taler** in your private account, **Account A**. Out of these 100 Taler you can transfer a chosen number of Taler into an **Account B**. You keep the remaining Taler in your private Account A. All participants face the **same** decision situation. The payoff of each participant consists of the following parts. You receive:

1. the number of Taler remaining in Account A.

2. a payoff from your transfer into Account B to **yourself**: For each Taler that you transferred into Account B you receive a payoff *of either 1 Taler or 0 Taler. Both events can happen with a probability of 50% and are determined by a random draw. Thus, when you transfer X Taler into Account B, you receive either a payoff of X Taler or of 0 Taler from Account B, depending on the outcome of the random draw.* At the same time you benefit from the transfers of the other three group members:

3. a payoff from the transfers of **the other three group members** into Account B: In addition to the payoff described in (2), you can get a payoff from the sum of the transfers of the other three group members into Account B, we call it $X_2 + X_3 + X_4$. *With a chance of 50% you get a payoff of $X_2 + X_3 + X_4$ Taler and with a chance of 50% you get a payoff of 0 Taler. The chance to receive this payoff depends on the same random draw as the chance to obtain part (2): Drawing the high payoff in (3) goes along with drawing the high payoff in (2), otherwise both parts of the overall payoff amount to 0 Taler.*

Thus, your overall payoff consist of the following three parts:

1. **The number of Taler in Account A: 100-X**
2. **The payoff from the own transfer X into Account B:** ***X or 0***
3. **The payoff from the transfers of the other group members into Account B:** ***($X_2 + X_3 + X_4$) or 0***

where X denotes the number of Taler, that you transferred into Account B and X_2, X_3, X_4 denote the transfers of the other three participants.

Total income in one round=(1)+(2)+(3)

This implies that your transfer into Account B also generates a payoff for the other members of your group: The fact that all participants face the same decision situation means, on the one hand, that you benefit from the transfers of your fellow group members into Account B as well as, on the other hand, that each other group member benefits from the Taler you transferred into account B. Your transfer into account B generates payoffs for the other group members in the same way as described above: *With a chance of 50%* ***all three group members*** *get a payoff of size X each and with a chance of 50% they get 0 Taler. Thus, in total 3*X Taler will be paid out to the other group members with a chance of 50%, 0 Taler otherwise.*

To illustrate, imagine the random draw as a coin toss:

There will be a coin toss and you receive -for example- the number of Taler transferred into Account B if head falls and 0 Taler if tail falls. *There will be only one coin toss. This coin toss determines the payoff of a participant from her own transfer in Account B and her payoff from the transfer of the others as well as the payoffs of the other three members from her transfer. The coin will be flipped once for each group (in each round) and the outcome holds for all group members. If head falls, each participant receivers the payoff from the own transfer and from the transfers of the others—and the others benefit from her transfer. If tail falls, all get 0 Taler from Account B.*

Above you can already see the computer screen with the decision situation as described above. There you type in the number of Taler you wish to transfer and then click on OK.
After all participants have made their decision, in each round you can see how many Taler the other group members have transferred. After the end of the experiment, a random draw will be drawn by the computer and you will see the size of your payoffs from each round on your screen (out of which one will be paid out, see Procedure section).

Do you have any questions concerning the instructions? If not, we will now proceed with the control questions, that serve your understanding of the procedure of the experiment. As soon as all participants have answered all questions, the actual experiment begins.

Part 2

In part 2 of the experiment you choose between lotteries with outcomes of different sizes. On your screen you will see the following table:

	Payoff C	**Payoff D**
1	56	56
2	48	72
3	40	88
4	32	104
5	24	120
6	4	140

Each row in the table represents a lottery. Each lottery consists of two payoffs in Taler, payoff C and payoff D, that can each be drawn with a probability of 50%. The exchange rate Taler-Euro is the same as in part 1 of the experiment: 100 Taler= 5 Euro. The six lotteries differ only with respect to the possible outcomes C and D, the probability is 50:50 in each lottery. You will choose between lotteries 1 to 6 and what consequences your decision has, will be explained to you on your screen. There will be two different decision situations. A random draw determines which of those two decisions will be relevant for your earnings from part 2. Both decisions have the same chance to be drawn to determine your payment in the end.

In case you have any questions during the experiment, please raise your hand! If you do not have any questions now, we will now proceed with part 2.