Trusting when risk and ambiguity create opportunities for exploitation

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ABSTRACT

This article studies the effect of uncertainty on reciprocity and trust using an experimental trust game in which the trustor's transfer is lost with some probability. Only the trustee will observe whether the transfer is lost or not. As a result, when not receiving anything back, the trustor cannot differentiate between a lost transfer and a selfish trustee. The results show that self-serving decisions of trustees increase with uncertainty. This increase is not driven by trustees who use their informational advantage and return zero. Instead, trustees continue to return positive amounts, but share less under uncertainty. Trustors also reduce transfers with increasing uncertainty. The data supports that risk attitudes, less sharing with trustees and the anticipation of trustee decisions contribute to this finding on trustor decisions.

1. Introduction

Reciprocity and the ability to trust in others being reciprocal are important to mediate agency problems. For example, a venture capitalist may need to trust the manager of a startup not to overstate losses or misappropriate funds when operating in a new market, and patients need to trust their specialist doctor to provide only necessary treatment, even if an alternative treatment option is more profitable for the doctor. Importantly, in many such cases there is no repeated interaction that disciplines self-serving actions of the agent. A large literature shows that individuals reciprocate even in non-repeated interaction, making trust in others profitable (Berg et al., 1995; Falk, 2007; Gächter & Fehr, 2002).

While the observation of reciprocity is widespread, the decision environment can influence the degree to which agents are reciprocal. Uncertainty is a factor of the decision environment that is present in many agency relationships and agents often have an informational advantage over the principal about this uncertainty. For example, the manager of a startup may face less uncertainty about market risks than their principal venture capitalist does, and, relative to the patient, a specialist doctor may face less uncertainty about the patients' health trajectory and the success rate of different treatment options. In many of these cases uncertainty is exogenous to the principal–agent interaction (i.e., it comes from a market environment or from a biological process) and may not establish but only add to an existing agency problem, because the principal already faces uncertainty about how the agent will act. Yet, uncertainty may affect reciprocity and reduce its capacity to mediate the agency problem, for example if it allows agents to establish a moral wiggle room and reduces the psychological

cost of exploiting the agent's position of power to allocate gains from a common resource between the principal and the agent.

This paper investigates how uncertainty affects trust and reciprocity. A large body of research has studied trust (Johnson & Mislin, 2011) and uncertainty (Wakker, 2010) separately, but less is known about their interaction. The current paper combines these two strands of the literature by using an experimental trust game in which the transfer from the trustor to the trustee is lost with some probability. Only the trustee will observe whether the transfer is lost. The experiment varies both the level of uncertainty (i.e., the probability of a lost transfer) and whether uncertainty is presented as *risk* (uncertainty with known probabilities) or as *ambiguity* (uncertainty with unknown probabilities, or Knightian uncertainty). The expected value of the transfer to the trustee is kept constant to maintain efficiency gains from trust. Nevertheless, compared to decisions observed in a standard trust game, reciprocation by trustees may be affected by uncertainty. Previous research (that, however, did not maintain efficiency gains from trust) indicated that uncertainty reduces trust (Vranceanu et al., 2012), but did not identify *how* it may do so.

There are two ways how uncertainty could affect trustee decisions. Trustees may become more selfish by hiding behind uncertainty and return nothing back to the trustor, or they may gradually reduce the share that they return under uncertainty. A possible reason for gradual reductions is that trustees use uncertainty to entitle themselves to a greater share of the overall social surplus, despite the fact that both trustees and trustors are exposed to uncertainty (i.e., the trustee may think 'I was lucky' instead of 'We were lucky'). Such behavior is suggested by a large literature on 'moral wiggling' (Dana et al., 2006). The

current paper tests whether uncertainty affects trustee decisions and is the first to identify whether trustees primarily hide behind uncertainty or if they keep a greater share of what they received without hiding behind uncertainty. Although the paper primarily aims to understand trustee decision, it also describes whether uncertainty affects trustor decisions, as trustors may share less under uncertainty, reduce transfers due to risk aversion and anticipate changes in trustworthiness.

This paper adds to existing research that examines the effect of uncertainty on decisions that are influenced by social preferences and is the first to show *how* uncertainty reduces reciprocity. In the existing literature, uncertainty typically implies that the recipient of a sharing decision does not receive the shared amount with certainty. Instead, the recipient faces a distribution of payoffs (usually either a positive amount or zero) with uncertainty about the realization of the final pay-off. Uncertainty may be described as a defined probability (risk) or an unknown probability (ambiguity). Most studies in this literature show that uncertainty reduces pro-social behavior, while others report no significant effect. Self-serving dictator choices increase in the presence of risk (Brock et al., 2013; Krawczyk & Le Lec, 2010, 2014), and the same is true when the receiver cannot differentiate if an outcome is based on a selfish choice or a random event (Andreoni & Bernheim, 2009). Risk is also used to excuse own selfishness in charitable giving and sharing decisions (Exley, 2016). Ambiguity, relative to risk, further increases self-serving decisions in the dictator game (Haisley & Weber, 2010), as ambiguity is used for moral wiggling. Such moral wiggling does not mainly 'excuse' self-serving decisions to others but serves to maintain the decision maker's self-image of being fair. The literature also suggests that risk-taking is little influenced by social preferences, as risk-taking decisions appear to be unaffected by whether own risk is correlated with the risk of others (Rohde & Rohde, 2011) and unrelated to social preferences (Brennan et al., 2008).

Applied to the trust game, these findings from the literature predict lower return transfers by trustees under uncertainty, as both risk and ambiguity may be used for moral wiggling, essentially using a random outcome to excuse keeping a larger share of the total surplus. The risk exposure of trustees may not directly affect trustor decisions, but there may be an indirect effect through risk-averse trustors, who face more risk regarding return transfers.

Similar conclusions emerge from several other studies that use the trust game and are closely related to the current one. Vranceanu et al. (2012) use a binary trust game (with decision options to transfer half or nothing) in which the transfer gets lost with a small probability and in which only the trustee knows whether the transfer is lost. Trustees can either transfer half or nothing back to trustors. Hence, they can and do 'hide behind probability' when returning nothing. Vranceanu et al. (2012) also argue that trustors do not anticipate this behavior, although they do not consider the effect of efficiency or risk preferences on trustor decisions.[1] Regner and Matthey (2015) and Van der Weele et al. (2014) also conduct trust games with uncertainty in which the return transfer from the trustee to the trustor is only implemented with some probability. When receiving nothing back, the trustor does not learn if this results from the trustee's choice or a random outcome. Van der Weele et al. (2014) find that uncertainty does not increase self-serving decisions while Regner and Matthey (2015) find that it does. Clots-Figueras et al. (2016) compare trust game decisions in which the efficiency factor is either known (i.e., equal to 3) or uncertain (either 2, 3 or 4). However, in the study by Clots-Figueras et al. (2016) the efficiency factor is always positive (i.e., the transfer cannot get lost), and its distribution does not vary across treatments. Clots-Figueras et al. (2016) find more frequent zero-returns under ambiguity, but not under risk, confirming results from the existing literature. Also Bejarano et al. (2018, 2021) study the trust game and the effect of negative random

shocks on the endowment received by trustors and trustees, with a primary interest to compare the effect of inequality because of the shock to the effect of inequality that is not due to a shock. The authors find that the random shock changes trustor behavior but has little effect on trustee decisions. However, compared to the current study, the random shock in those two studies affects private endowments of the trustor or the trustee and does not generate asymmetric information between the trustor and the trustee, while the random shock in the current study affects a common resource shared between the trustor and the trustee. In addition, the current study provides the trustee with an informational advantage that allows the trustee to hide self-serving decisions behind uncertainty.

The effect of random shocks on reciprocity has also been studied in the gift exchange game, which – similar to the trust game – models reciprocal interactions between two players, an employer and a worker. Rubin and Sheremeta (2016) investigate if employers pay bonuses to workers after observing an outcome that is jointly determined by effort chosen by the worker and a random shock. They find that reciprocity is reduced, both when the employer observes the effort choice and the shock separately and when only observing their joint outcome. Davis et al. (2017) replicate this study and confirm the result when the employer cannot attribute the observed outcome to either effort or the shock. This is consistent with other research showing that observable exogenous shocks do not lead to the breakdown of reciprocal cooperation (Gerhards & Heinz, 2017).

This study extends these papers by identifying if self-serving trustee decisions increase at the extensive or intensive margin, hence the degree to which trustees will keep everything under uncertainty (the extensive margin) or, alternatively, continue to reciprocate but gradually return a lower share of what they received (the intensive margin). No previous paper has investigated the role of the extensive or intensive margin in such self-serving decisions. Using different levels of risk, ambiguity, and continuous choice variables allows to determine if selfishness is driven by opportunistic behavior, hence taking advantage of exclusive information and hiding behind uncertainty (the extensive margin), or if selfishness increases gradually, with trustees becoming 'a little bit' more selfish without taking advantage of exclusive information (the intensive margin). Previous studies could not distinguish between the extensive and the intensive margin because they used binary decision variables (share or do not share), did not vary the level of uncertainty or the distribution of the efficiency factor, or designed experiments to identify types of decision makers that either exploit their exclusive information or not. Extending the existing literature by using different levels of uncertainty (i.e., a range of probabilities and ambiguity) is informative because these have been shown to affect individual decisions under uncertainty (Wakker, 2010) and it appears likely that they also affect social decisions. The differentiation into the extensive margin and the intensive margin is also important for understanding how self-serving decisions (re)emerge in cooperative environments under risk. For instance, a self-image of being fair or reciprocal, as required when explaining self-serving decisions with moral wiggling, can hardly be maintained when returning nothing (i.e., when not reciprocating) at the extensive margin. By contrast, such a self-image of being a pro-social reciprocator may be maintained when trustees continue to return positive amounts, while reducing the share of the joint surplus that they return to trustors at the intensive margin.

The experimental results show that uncertainty increases self-serving decisions of trustees. Some trustees become fully selfish at the extensive margin, but the main effect is found at the intensive margin. Self-serving decisions increase with risk and are more common under ambiguity than under risk. Trustors also reduce their transfers under uncertainty and the data supports more self-serving decisions, risk attitudes and the anticipation of selfish trustee decisions as possible explanations.

The article is organized as follows: Section 2 describes the experiment, Section 3 the hypotheses and Section 4 the results. Section 5 summarizes and discusses the findings.

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[1] Vranceanu et al. (2012) use risks of 1 percent and 10 percent of a lost transfer without adapting the efficiency factor.

Table 1
Treatments 1–13.

Treatment	1	2	3	4	5	6	7	8	9	10	11	12	13
π (in percent)	0	10	0–20	20	10–30	25	15–35	40	30–50	50	40–60	80	70–90
f		3		3.5			3.75			4		5		6		15

2. Experimental game and implementation

The study used an experiment based on the trust game (Berg et al., 1995). In this game a first player, the trustor, receives an endowment of $e = 10$ and can transfer any amount $\tau \leq e$ to a second player, the trustee. The remaining amount $(e - \tau)$ is available to the trustor with certainty. τ is multiplied by f ($f = 3$ in the standard trust game) and provided to the trustee. The trustee can then decide how much $Y \leq \tau \times f$ to return to the trustor. The logic of the game entails that trustors transfer a higher τ when trusting that trustees return some of the amount received, and trustees return $Y > 0$ to reciprocate trust.

A large body of literature shows that positive transfers $\tau > 0$ are common in the trust game and that trustees reciprocate, even in one-shot interaction (Camerer, 2003; Glaeser et al., 2000; Johnson & Mislin, 2011). τ and Y are usually positively correlated but some individuals also make selfish-rational choices (i.e., $\tau = 0$ and $Y = 0$).

The game used this basic structure (Treatment 1, i.e., with $f = 3$ and $\pi = 0$) and further modifications that introduced π, the probability that the transfer from the trustor to the trustee is lost (Treatments 2–13, $f > 3$ and $\pi > 0$). In the modified framework $\tau \times f$, which in the standard framework always reaches the trustee, is lost with probability π. In game-theoretic terms this can be interpreted as a move of nature, where nature destroys the transfer with probability π and does not destroy it with probability $1 - \pi$. When $\pi > 0$, the expected value of the transfer ($\tau \times (1 - \pi) \times f$) is maintained across decisions as f increases at the same rate as $(1 - \pi)$ decreases (except for a minor deviation in Treatments 2 and 3).[2] This allows the social efficiency gain from τ to remain constant.

Uncertainty was described in two ways, once as a defined probability (risk) and once as a 20 percent probability interval (ambiguity) for which the midpoint of the interval corresponded to the defined probability in another treatment. That is, the size of ambiguity remained constant while varying the mid-point. It was explained to participants that the probability could be anywhere on this interval. The exact probability was randomly determined using a draw from a uniform distribution. Participants did not know the exact probability or the distribution from which it was drawn.

For example, in Treatment 6, the factor of multiplication was $f = 4$ and the probability of a lost transfer was $\pi = 0.25$, hence the expected efficiency of the transfer remains $4 \times (1 - 0.25) = 3$; in Treatment 9, the factor was $f = 5$ and π between 0.3 and 0.5. Table 1 shows the pairs of f and π (the probability with which τ is lost and the trustee receives nothing) for each treatment.

When a transfer is successful, the trustee receives $f \times \tau$ and can return any amount Y, with $0 \leq Y \leq f \times \tau$, to the trustor. Back-transfers Y always reach the trustor. Hence, the trustor does not know whether the trustee will be trustworthy and reciprocate when making a decision. The trustor also does not know if the transfer will be lost and can only update this information when sending $\tau > 0$ and when the trustee returns a positive amount ($Y > 0$). Otherwise, the trustor cannot differentiate between the case that the trustee would have reciprocated but could not do so because the transfer was lost, and the case that the trustee chose to keep the full amount. By contrast, the trustee faces no uncertainty when deciding over Y because the decision of the trustee is made after the realization of nature's move.

The game was implemented with 112 students as volunteer participants (average age 22.5; 53 percent female) in a computer laboratory using ztree (Fischbacher, 2007). Participants made decisions using the strategy method over the 13 treatments as described in Table 1 in the role of trustors (40 participants) or trustees (72 participants). Trustor and trustee roles were randomly assigned when entering the laboratory and were maintained throughout the experiment. Trustor and trustee pairs randomly changed each round (with each round including one decision under risk and one under ambiguity). The strategy method was chosen to cover the full decision space of trustees, as trustees had to respond to every potential decision of the trustor.[3] Hence, the trustor had to make 13 choices (1 for $\pi = 0$, 6 for $\pi > 0$ under risk and 6 for $\pi > 0$ under ambiguity) to transfer any $0 \leq \tau \leq 10$. The trustee had to specify a response to 130 possible transfers received (10 for $\pi = 0$, 60 for $\pi > 0$ under risk and 60 for $\pi > 0$ under ambiguity; if the trustor chooses $\tau = 0$, the trustee cannot specify a response). This provides data on return transfer by trustees for every possible trustor decision and across all levels of uncertainty. Participants made decisions on the same screen for a given level of uncertainty (i.e., for risk and ambiguity together; see appendix A). We also note that our sample of 112 participants compares to 90 students in the study by Vranceanu et al. (2012), which used the existing design closest to our study and which was sufficiently powered to identify significant effects for trustors and trustees. Furthermore, our data has more observations per individual (13 or 130 instead of 3 per individual), which should further reduce the within-individual variance of the data.

Participants were paid their outcome for two randomly selected treatments at the end of the experiment. Participants did not receive information on the decisions of others until the end of the experiment when the final payoffs were determined.[4] Participant earnings were based on 'experimental dollars' in the experiment that were converted into local currency (Euro) at the end of the experiment. One experimental dollar paid 25 cents, a rate announced at the beginning of the experiment. Total payments for participation in the experiment were based on a show-up fee of 2 or 5 Euros and a variable payment based on decisions.[5] Participants earned between 2 and 39.50 Euros, on average 7.85 Euros for their participation in the experiment, which typically lasted for less than one hour. A basic sociodemographic questionnaire for participants to complete followed the experiment.

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[2] In Treatments 2 and 3, $(1 - \pi) \times f$ is 3.15 instead of 3 to keep the decimal digits in f within hundreds and to use (intuitive) values of π that are multiples of 5 percent.

[3] There is no difference between the choice and the strategy method for the trustor in this game. Further analysis included in appendix C shows that results using the strategy method are replicated for both trustors and trustees when using the choice method.

[4] The number of trustors and trustees in a total of 6 sessions was not always equal, but the decisions made in the strategy method were always matched with another participant currently in the laboratory. Trustors and trustees were not necessarily paid for the same treatment because the random selection of the treatment for payoffs was made separately for each participant. Controlling for trustor and trustee composition in the laboratory does not affect results.

[5] 2 Euros corresponded to the hourly minimum wage at the time in Slovakia, the location of the experimental laboratory. Two different show-up fees were used for recruitment because the laboratory rules changed from the first four to the last two sessions. Most participants (71 percent) received a show-up fee of 2 Euros and the remainder (29 percent) a show-up fee of 5 Euros. Controlling for the show-up fee did not affect results. Payments for experimental decisions (i.e., the conversion rate between experimental dollars and Euros) were the same across sessions.

3. Hypotheses

The hypotheses first consider the decisions of trustees and subsequently the decisions of trustors. When assuming selfish-rational preferences, trustees keep the full amount ($\tau \times f$) in the second stage, and, as a result, trustors transfer nothing in the first stage. However, the existing literature suggests that most trustors make positive transfers and that most trustees return positive amounts. Similarly, $\tau > 0$ and $Y > 0$ were expected to be commonly observed. The empirical question was if τ and Y change with uncertainty.

Based on findings from the existing literature (Regner & Matthey, 2015; Vranceanu et al., 2012), trustees are hypothesized to hide behind uncertainty at the extensive margin by choosing $Y = 0$ more frequently when $\pi > 0$. Such an increase of self-serving decisions would be consistent with models in which trustees want to maintain a social image of being pro-social (Andreoni & Bernheim, 2009) but would like to keep as much to themselves as possible as long as this does not affect their social image.

Hypothesis 1. Trustees choose $Y = 0$ more frequently in treatments with $\pi > 0$ than in the treatment with $\pi = 0$.

Self-serving decisions of trustees may also gradually increase with uncertainty. Such a gradual increase could be observed through an increase of $Y = 0$ decisions when π increases, particularly when decision makers are concerned about their social image. Grossman (2015) provides evidence and arguments that an increase in π will decrease the likelihood that, when the trustor observes $Y = 0$, this outcome is the result of a self-serving decision. An increase in π may therefore reduce the trustor's suspicion of facing a selfish trustee when not receiving anything back, and hence the risk that a $Y = 0$ decision reduces social image.

In addition, trustees may be also concerned about their self-image of being a reciprocator and therefore refrain from choosing $Y = 0$. Previous research (e.g., Falk, 2021) suggests that self-image matters for social decisions. However, even when concerned about their self-image, trustees may reduce the share returned to the trustor, for example, because greater uncertainty allows them to use a more self-serving selection or interpretation of reciprocity norms to evaluate their own decision. Trustees could believe that the trustor also interpret reciprocal norms more in favor of the trustee when π increases, reducing the social image cost of a lower Y, or interpret reciprocal norms in a more self-serving way when facing themselves, reducing the self-image cost of a lower Y.

Based on these arguments and findings from the literature, the share of the received amount returned by trustees ($\frac{Y}{\tau \times f}$) was hypothesized to be lower under ambiguity than under risk, as indicated by results from Clots-Figueras et al. (2016), and to decline with increasing risk (i.e., there is an intensive margin of self-serving decisions).

Hypothesis 2. Trustees gradually return a lower share of what they received ($\frac{Y}{\tau \times f}$) for greater levels of π (i.e., $\frac{d(\frac{Y}{\tau \times f})}{d\pi} < 0$) and under ambiguity relative to under risk.

It remains an open empirical question if self-serving decisions by trustees are driven by hiding behind uncertainty (the extensive margin) or by a gradual decrease in the share returned while maintaining $Y > 0$ (the intensive margin). Dana et al. (2006, p.68) argue that decision-makers do not want to appear as being selfish to others and themselves, but it is not apparent if this will lead to a greater effect at the extensive or intensive margins. An argument predicting a greater importance of the intensive margin is that taking advantage of exclusive information may be more threatening for a self-image of being fair than reducing the share returned 'just a little bit' at the intensive margin, which could be justified by moral wiggling. Based on this argument, it was hypothesized that the effect at the intensive margin would be greater than the effect at the extensive margin.

Hypothesis 3. In the overall effect of π in reducing the average share returned, the effect at the intensive margin, hence a decrease in the share returned while maintaining $Y > 0$, is greater than the effect at the extensive margin, hence a reduction in the average share returned due to a higher frequency of $Y = 0$ decisions.

Based on the previous literature, trustors were expected to make positive transfers, but to transfer less when $\pi > 0$, and less under ambiguity than under risk (Brock et al., 2013; Exley, 2016; Haisley & Weber, 2010; Krawczyk & Le Lec, 2010). Furthermore, risk aversion with respect to own outcomes may lead to lower transfers because a higher risk that τ is lost increases the variance of Y. Trustors may also be averse to compound risk (Abdellaoui et al., 2015), as they face a combination of several sources of uncertainty — human and non-human. Trust has also been described as a decision under ambiguity (Li et al., 2019), as uncertainty with human source can be understood as ambiguous uncertainty (i.e., not specified by a known probability distribution), and ambiguity aversion could result in a reduction in transfers.[6] Furthermore, trustors may anticipate increasingly self-serving trustee decisions.[7] All of these factors predict lower transfers by trustors under uncertainty.

Hypothesis 4. Trustors choose lower transfers τ in treatments with $\pi > 0$ relative to the treatment with $\pi = 0$ and under ambiguity compared to risk for a given expectation of π. τ becomes smaller when uncertainty increases (i.e., $\frac{d\tau}{d\pi} < 0$).

4. Results

4.1. Trustee decisions

It was hypothesized that the frequency of no-returns ($Y = 0$) would be higher and that the average share of the received amount returned by trustees would be lower when $\pi > 0$.[8] Fig. 1(a) and (b) confirm these hypotheses. $Y = 0$ decisions are significantly more common under uncertainty (t-test: $p = 0.07$; Wilcoxon ranksum test: $p = 0.01$) and the share returned is significantly lower when $\pi > 0$ than when $\pi = 0$ (both when risk and ambiguity are taken together or when investigated separately; all $p \leq 0.01$ both in t-tests and Wilcoxon ranksum tests of individual averages). Both effects for the share returned and $Y = 0$ decisions are also statistically significant (with $p \leq 0.01$) in fixed effects regressions, which test the within-individual treatments more efficiently than t-tests or ranksum tests.

Result 1. *Trustees return $Y = 0$ more frequently when $\pi > 0$ than when $\pi = 0$.*

It was also hypothesized that self-serving decisions would increase with uncertainty and that transfers would be lower under ambiguity than under risk. Fig. 2(a) and (b) support these hypotheses. Table 2 reports results from fixed effects regressions showing that the share returned significantly decreases when uncertainty increases ($p \leq 0.01$).

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[6] Note that Li et al. (2019) did not model ambiguity as probability intervals as in the current paper, which limits the applicability of their results to the present study. There are also studies that argue that trust is not well-understood as a risk-taking decision (Eckel & Wilson, 2004; Houser et al., 2010).

[7] However, Vranceanu et al. (2012) argued that they do not.

[8] This share ($\frac{Y}{f \times \tau}$) captures the most straightforward sharing rule for trustees and is used in the following. Using the nominal amount transferred back, while controlling for the amount transferred and the amount received, provides the same results. Another alternative decision rule would be a Y that corresponds to τ plus an additional amount ϵ. However, this does not reflect any sharing of joint surplus by the trustee because it would imply that all risk is taken by trustors and all benefits from risk go to the trustee. $Y = \tau + \epsilon$ is also not clearly supported as a typical decision in the data of trustee decisions.
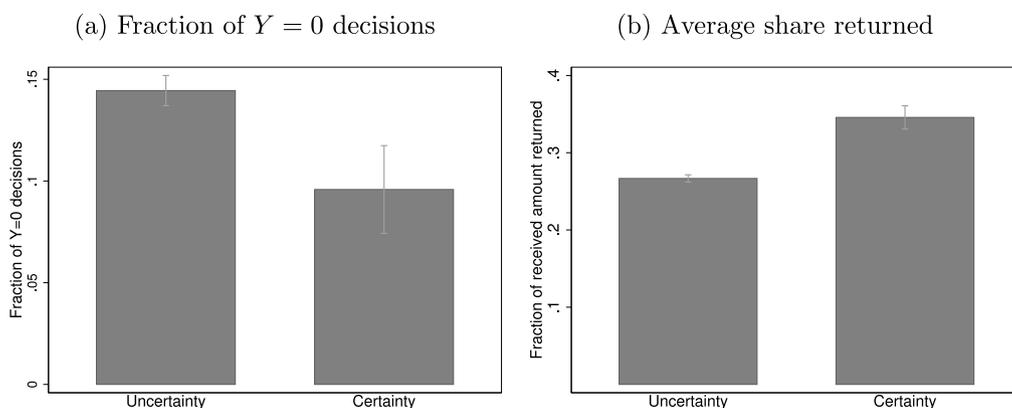
(a) Fraction of $Y = 0$ decisions   (b) Average share returned

Fig. 1. Decisions of trustees under certainty and uncertainty.

(a) by π (b) by risk and ambiguity
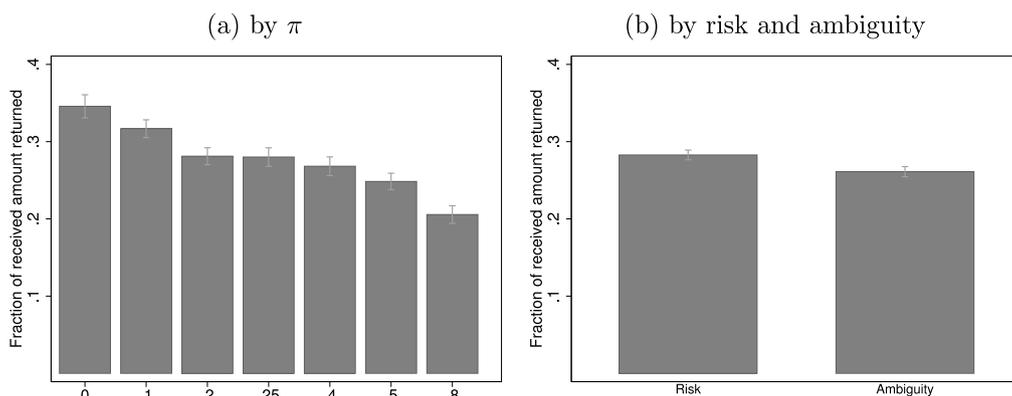

Fig. 2. Fraction of $\tau \times f$ returned by trustees.

The effect of ambiguity (returning 26 percent instead of 27 percent) appears small and is statistically insignificant in a t-test ($p = 0.40$) and a Wilcoxon ranksum test ($p = 0.39$) but is statistically significant ($p = 0.01$) in fixed effects regressions (Table 2, column 1). The results for π and ambiguity remain unchanged when controlling for τ (column 2), which shows that trustees reciprocate in a conditionally cooperative manner, as τ increases the share returned.

Providing further detail on the results, appendix Figure B1 shows that the decrease in transfers visible in Fig. 2(a) is observed for both risk and ambiguity. In addition, appendix Figure B2 highlights that $Y = 0$ decisions increase strongly when moving from $\pi = 0$ to $\pi = 0.1$ but remain at a similar level with increasing π (reporting no significant effect in a simple correlation [p = 0.256] and fixed effects regressions [p = 0.167]). Hence, the decrease in the share returned by trustees is not driven by an increase of $Y = 0$ decisions when π increases.

Result 2. *Trustees reduce the share returned when uncertainty increases. There is also support for more self-serving decisions under ambiguity than under risk, but this result is only observed in fixed effects regressions.*

The results in Table 2 also inform the magnitude of the observed effect. An increase of uncertainty by 10 percentage points leads to a reduction of the share returned by 1.5 percentage points (a large effect, as the average share returned is 27 percent).[9] Overall, the share

returned declines from 34.6 percent when $\pi = 0$ to 20.6 percent when $\pi = .8$, an absolute decrease of 14.0 percentage points and a relative decrease of 40.5 percent.

Furthermore, Table 2 quantifies the effect of describing π as ambiguity, that is, as a probability interval instead of a point value. The share returned is approximately 1.3 percentage points lower under ambiguity, a large effect, considering that ambiguity refers to a probability interval of 10 percent around the respective risk. That is, trustees act as if the (unknown) probability was not at the midpoint of 0 in an interval from −10 to +10 percent, but at +5 percent or greater. Decision makers would be expected to use the midpoint of the interval in the absence of any additional information if there was no additional effect of ambiguity, as the principle of insufficient reason would apply (Machina & Siniscalchi, 2014). By contrast, further tests show that the effect of ambiguity is not significantly different from the upper bound of the probability interval (+10 percent; $p \geq .12$ for all specifications corresponding to columns 1–4 in Table 2). Hence,

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[9] The effect is robust to using indicator variables for uncertainty levels instead of a continuous variable. They also remain when including period dummies, which can control for order effects, as treatments 1–13 were always in the same order. Period controls themselves are not significant (except for period 3), indicating that lower return transfers are not driven by declining reciprocity over the time of the experiment. When including both π and a

'period' variable, the period variable is never close to statistical significance and has much less explanatory power than π based on all of the following comparisons: (1) Comparing the R^2 when using either period or π; (2) comparing Shapley values of period and π in regressions that include both variables; or (3) comparing t-values in regressions with both variables, as the t-values of π are between twice and nine times as large as those of the period variable. This finding is visible for all specifications but more pronounced for those that focus on the intensive margin. Fig. 2(a) further supports that it is π and not just a trend of a declining fraction returned over the periods, as there is almost no decline between period 3 (with $\pi = .2$) and period 4 (with $\pi = .25$), corresponding to a small change in π, and a large decline between period 6 (with $\pi = .5$) and period 7 (with $\pi = .8$), corresponding to a large change in π.

Table 2
Determinants of trustee and trustor decisions.

	Trustee decisions				Trustor decisions
	(1)	(2)	(3)	(4)	(5)
π	−0.153***	−0.153***	−0.180***	−0.180***	−4.462***
	(0.029)	(0.029)	(0.031)	(0.031)	(0.458)
Ambiguity	−0.013**	−0.013**	−0.011*	−0.011*	−0.525**
	(0.004)	(0.004)	(0.005)	(0.005)	(0.201)
τ		0.007*		−0.001	
		(0.003)		(0.002)	
Constant	0.332***	0.295***	0.385***	0.389***	4.573***
	(0.010)	(0.019)	(0.011)	(0.017)	(0.197)
N	72	72	71	71	40
n	9360	9360	8043	8043	520

Fixed effects regression results of determinants of the percentage transferred back by the trustee and the amount transferred by trustors. π (with values between 0 and 0.8) describes the probability that the transfer is lost. τ controls for the amount sent by the trustor. N refers to the number of individuals and n to the number of observations used in the estimation. Columns 1 and 2 include all choices while columns 3 and 4 only include $Y > 0$ choices. *** indicates p<0.001, ** p<0.01 and * p<0.05. Standard errors (in brackets) are clustered at the level of the individual.

ambiguity leads to an additional increase of the moral wiggle room to keep a greater share of the common surplus.

A decreasing share returned by trustees, as observed in columns 1 and 2 of Table 2, may be driven by 'hiding behind uncertainty' at the extensive margin; hence trustees who choose $Y = 0$, or by small changes in behavior at the intensive margin, as trustees choose $Y > 0$ but reduce the share returned when π increases.[10] Fig. 1(a) shows that hiding behind uncertainty at the extensive margin is observable, as $Y = 0$ choices are more common under uncertainty. Further testing shows that the increase in $Y = 0$ decisions is already statistically significant when comparing $Y = 0$ decisions under $\pi = 0$ to $Y = 0$ decisions when $\pi = 0.1$. The share of $Y = 0$ decisions remains at about the same level for $\pi > 0.1$ as it is observed for $\pi = 0.1$. Hence, fully self-serving decisions at the extensive margin increase when $\pi > 0$, but the explanatory importance of the extensive margin for the total effect may be limited, as self-serving decisions at the extensive margin do not continue to increase when uncertainty increases.

To capture decisions that can be attributed to the intensive margin, columns 3 and 4 of Table 2 describe the analysis of a reduced sample that includes only $Y > 0$ decisions, hence when the trustee did *not* hide behind uncertainty.[11] The results show that hiding behind uncertainty does not appear to be the (main) driver of increased selfishness, as self-serving decisions continue to increase with π when $Y = 0$ decisions are excluded.

How much of the increase in self-serving decisions is due to the extensive relative to the intensive margin? The following calculation compares the total reduction in transfers under $\pi > 0$ relative to $\pi = 0$ for the full sample to the reduction in transfers attributable to the intensive margin (i.e., the observed reduction when $Y = 0$ decisions are excluded from the analysis). For the full sample, capturing the extensive and intensive margins combined, the share returned to trustors when $\pi = 0$ is 0.35, and the average share returned when $\pi > 0$ is 0.27, a reduction of 8 percentage points or 22.9 percent relative to the share returned when $\pi = 0$. When excluding decisions at the extensive margin (i.e., when excluding $Y = 0$ decisions), both under certainty and uncertainty, the share returned decreases from 0.38 to 0.31, a reduction of 7 percentage points or 18.5 percent relative to the share returned

when $\pi = 0$.[12] Thus, most – about 81 percent – of the reduction appears to occur at the intensive margin, confirming results in Table 2 which show that the coefficient of π did not become smaller when excluding $Y = 0$ decisions.[13]

Result 3. *Self-serving decisions primarily increase at the intensive margin, explaining more than 80 percent of the overall reduction in return transfers.*

4.2. Trustor decisions

It was hypothesized that trustors transfer lower amounts when $\pi > 0$, transfer less under ambiguity than under risk and continue to decrease transfers when π increases. Fig. 3 provides support for these hypotheses. Average transfers (τ) decline from 4.4 when $\pi = 0$ to 0.5 when $\pi = .8$. The decrease in τ is statistically significant, as visible in column 5 of Table 2, and the observed effect is large in magnitude, as an increase of π by 10 percentage points leads to a reduction of τ by 0.45, which is more than 10 percent of the amount transferred when $\pi = 0$. Transfers are also lower under ambiguity than under risk. The observed effect of ambiguity is large, as trustors do not only decide as if the 'worst case' in the probability interval would be realized, but transfer even less than they would at the lower end of the probability interval (i.e., 0.53 less instead of 0.45 less).

Result 4. *Trustors transfer lower amounts to trustees when $\pi > 0$ than when $\pi = 0$. They also transfer less under ambiguity than under risk for a given expectation of π. Transfers decrease when π increases.*

The decrease in τ may be influenced by several factors: preferences to share with trustees, risk attitudes (about receiving more volatile Y), ambiguity aversion, and the anticipation that trustees return a lower share when $\pi > 0$. The existing literature indicates that decision-makers share less under uncertainty (Brock et al., 2013; Exley, 2016; Krawczyk & Le Lec, 2010), that the risk exposure of their counterparts does not affect choices (Brennan et al., 2008; Rohde & Rohde, 2011), and that trustors may not anticipate increasingly self-serving decision by trustees (Vranceanu et al., 2012). However, they may adapt their decisions as a response to greater risk when it affects their own payoffs, as in the current study. Appendix D describes further analysis investigating if the data supports the influence of these three factors. This shows that increasingly self-serving decisions, own-regarding (expected-utility-type) risk aversion, and some anticipation may contribute to the observed decline in transfers.

5. Discussion

The results show that uncertainty reduces both reciprocity and trust. Trustees make more self-serving decisions, both at the extensive margin by hiding behind uncertainty and at the intensive margin by gradually reducing the share that they return to trustors. The effect is stronger at the intensive margin, explaining about 80 percent of the overall effect.[14] Trustors also reduce transfers when uncertainty increases. Risk attitudes, reduced sharing with trustees when $\pi > 0$ and the anticipation of changing trustee decisions contribute to this finding.

Hence, uncertainty undermines trust and reciprocity, which have been widely studied and shown to mediate agency problems, as modeled in the trust game, in environments without uncertainty (Berg et al.,

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[10] Note that some $Y = 0$ decisions may capture decisions at the intensive margin if the amount transferred under $\pi = 0$ is close to zero and a slight reduction at the intensive margin subsequently leads to $Y = 0$.

[11] Columns 3 and 4 include decisions for all π but the results are very similar when further excluding decisions under $\pi = 0$ from this sample.

[12] The exact numbers are (.3457119 - .2667063)/.3457119 = .22853017 for all participants and (.3823542 - .3117347)/.3823542 = .18469655 for all those who transfer back $Y > 0$.

[13] The overall relative reduction is .22853017 and the relative reduction within $Y > 0$ decisions is .18469655. .18469655/.22853017 = .80819329.

[14] Observing a 18.47 percent (or 7.06 percentage point) reduction attributable to the intensive margin relative to a total reduction of 22.85 percent (or 7.90 percentage points).
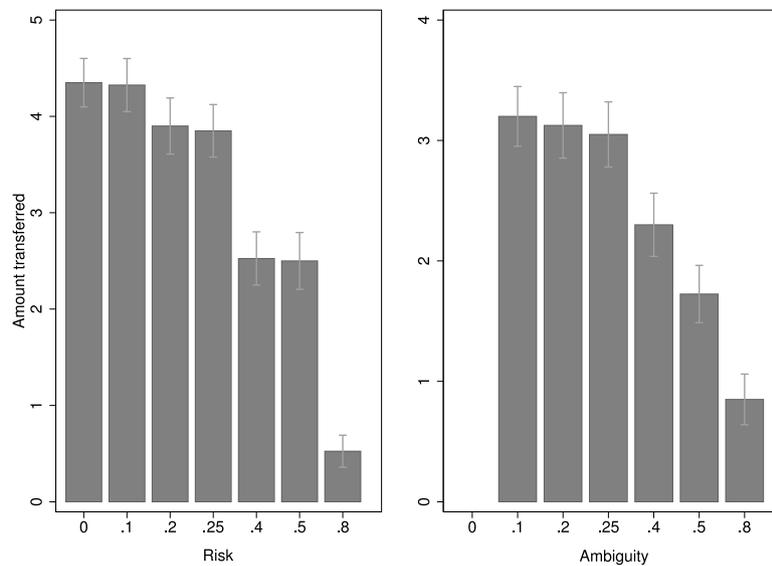
Fig. 3. Transfers of trustors by risk and ambiguity.

1995; Falk, 2007; Gächter & Fehr, 2002). Uncertainty is present in many real-life agency relationships. For example, startups may blame 'the market' for the complete loss of a venture capitalist investment, taking advantage of exclusive information at the extensive margin, or use market uncertainty to appropriate a larger share of investment profits at the intensive margin. Medical specialists can induce demand for non-required services when patients face uncertainty about their needs and may do so by providing unnecessary treatment at the extensive margin or by increasing treatment intensity at the intensive margin.

Understanding that uncertainty undermines reciprocity even when it does not introduce inefficiency and whether it does so at the extensive or the intensive margin is important to determine the best policy response in these fields. For example, legal enforcement may deter decisions of self-serving service providers at the extensive margin, as fraudulent decisions can be defined as illegal and prosecuted (e.g., in cases of financial fraud or medical treatment that was not required). By comparison, laws are less well-suited to address self-serving decisions of agents at the intensive margin because such decisions (e.g., high bonuses despite poor performance or unnecessarily high scope of medical treatment) are harder to define. The current findings show that maintaining efficiency is not sufficient to offset the undermining effect of uncertainty on reciprocity and that self-serving decisions at the intensive margin are important, while previous studies only argued for self-serving decisions at the extensive margin. Policies such as increasing the ability of trustors to understand drivers of self-serving trustee decisions or policies that reduce uncertainty may therefore be promising, in addition to relying on legal enforcement, which will primarily address self-serving decisions at the extensive margin.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

Appendix A. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.socec.2023.101994.

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