The investment game with asymmetric information *

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Abstract

We analyze the effects of introducing asymmetric information and expectations in the investment game (Berg et al., 1995). In our experiment, only the trustee knows the size of the surplus. Subjects' expectations about each other's behavior are also elicited. Our results show that average payback levels increase with the average amount sent. Asymmetric information does not reduce the amounts sent and returned, as compared with previous experimental studies. The first movers' choices increase with their expectations about the second movers' payback, whose choices depend in turn on the difference between expected and actual amounts received.

Keywords: game theory, trust, reciprocity
JEL classification: C70, C91, D63, D64

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*The authors gratefully acknowledge the suggestions and comments made by James Cox, Werner Güth, John Hey, Amnon Rapoport, and two anonymous referees. For financial support, we thank the European Network for the Development of Experimental Economics and its Application to Research on Institutions and Individual Decision Making.

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1 Introduction

An increasing body of literature in experimental economics has provided evidence of cooperative behavior in situations where noncooperation is a dominant strategy, and in which no enforcing mechanisms such as reputation concerns, repeated interactions, contractual pre-commitments, or punishment threats support a cooperative equilibrium.

In a previous investigation of the investment game, Berg et al. (1995) argued that "trust can be viewed as a behavioral primitive," and that an agent's decision to reward trust may depend on this agent's subjective interpretation of the inherent motives of the trustor. This is in accordance with the hypothesis that economic agents are evolutionarily predisposed to produce cooperative outcomes using their ability to "ratify one another's volitional states" (Hoffman et al.(1998)). Choosing different levels of "trust" can be seen as a way to signal some kind of "cooperative predisposition," which, in turn, triggers reciprocal behavior. In the experiment reported here, our aim is to test whether trust and reciprocity survive as patterns of behavior even in a setting where individual decisions have very low informational content about any predisposition to be cooperative. This is achieved by using an asymmetric information structure in an investment game in which only the player who is in charge of dividing the surplus is aware of its true size.

The investment game is a sequential two-person game. The first mover can send any amount of his or her initial endowment to an anonymous counterpart. The amount received by the second mover equals the amount sent multiplied by a factor greater than one. The second mover can return to the first mover any amount taken from his or her initial endowment plus the amount received. Backward induction suggests that opportunistic players would not voluntarily engage in any transaction unless they expect trust and reciprocity to play a role in determining the behavior of their counterparts.

In our experiment only the trustee is aware of the size of the surplus obtained so that the trustor cannot tell if a low return corresponds to a low or high level of reciprocity. In a similar study, Güth et al. (1996) use a two-level ultimatum game and conclude that "received generosity induces own generosity," which they interpret as some sort of indirect reciprocity. Nevertheless, reciprocal behavior in their case is confounded with the risk of being punished by a third party who has veto power. The investment game with asymmetric information, in contrast, allows us to test *direct* (i.e., bilateral) reciprocity when the decision to reciprocate is risk free. Additionally, we ask for subjects' expectations about the behavior of their counterparts, which allows for a better interpretation of the motives that lead to specific patterns of behavior.[1]

The paper is organized as follows: in Section 2 we describe our behavioral hypotheses for the investment game with asymmetric information; Sections 3 and 4 describe the design and the procedures of our experiment; Section 5 reports the results and the analysis of the data; and Section 6 contains concluding remarks.

2 Theoretical and behavioral hypotheses

We modify the investment game (Berg et al. (1995)). In our design the two players A and B have equal initial endowment ω. The value of the initial endowment is common information. In the first stage of the game,

[1] Mitzkewitz and Nagel (1993) also examine the motives that drive individual behavior in bargaining games with asymmetric information. Nevertheless, they concentrate on the learning effects that arise from repetition of the game, while our experiment is a one-shot game.

player A (the "trustor") may send any amount $0 \leq a \leq \omega$ from his or her endowment to player B (the "trustee"). The amount sent is then multiplied by a stochastic factor m, which takes the value $m = 2$ with probability $p \in (0,1)$, or $m = 4$ with probability $(1-p)$. Only player B learns the true value of the multiplier m.

In the second stage, after observing how much surplus has been generated, player B decides which amount of money b to return to A[2]. The amount of money that B may send to A is $0 \leq b \leq ma + \omega$. The theoretical solution of the game (subgame perfect Nash equilibrium) is: $a = 0$ for the first mover, and $b(a) = 0$ for all a for the second mover. Thus, the original version of the investment game and the investment game with asymmetric information described here have the same equilibrium solutions. The first hypothesis of our analysis refers to the consistency of the subjects' behavior with the theoretical prediction.

Hypothesis 1 (Subgame Perfect Nash equilibrium) *Both the amount sent and the payback are zero, i.e.,* $a = 0$, *and* $b(a) = 0$ *for all* $a \in [0, \omega]$.

We extend the definition of trust given by Coleman (1990) and Berg et al. (1995) by imposing some considerations on the subjects' expectations about each other's actions. Let $E_A(b)$ represent A's expectation about B's payback, and let $E_B(a)$ represent B's expectation about the amount sent by A. If the first mover sends a positive amount of money ($a > 0$) and he or she expects to receive back at least the same amount (i.e., if $E_A(b) \geq a$), we say that she or he "trusts" the second mover. In response to a trusting behavior (and if the amount received is greater than the amount

[2]The second stage of the game is equivalent to a dictator game; i.e., the player that has to move at this stage must decide how much to send to his or her counterpart. This decision will end the game and the interaction between the two players.

expected), the second mover may return an amount greater than or equal to the amount received. This behavior could be based on reciprocity, altruism, and inequality aversion. Thus, we propose

Hypothesis 2 *When* $E_A(b) \geq a$*, then* $a > 0$*; and when* $(a - E_B(a)) > 0$*, then* $b \geq a$*.*

If a positive payback is simply motivated by altruism, then it should not depend on the level of trust shown by A. On the other hand, reciprocity and inequality-aversion motives should cause levels of trust to be positively correlated with payback levels. Therefore, the third hypothesis concerns the type of correlation between the amounts sent and returned.

Hypothesis 3 *The amounts* a *and* b *are positively correlated.*

The fourth hypothesis is exclusively related to our design, which allows trustees with multiplier $m = 4$ to hide their opportunism by pretending that $m = 2$. If so, the reward of trust should not depend on the value of the multiplier.

Hypothesis 4 *The reward* $b(a)$ *of trust level* a *is the same for* $m = 2$ *and* $m = 4$*.*

Hypotheses 1 and 4 are standard in the sense that they claim opportunistic behavior. Hypotheses 2 and 3 predict other-regarding preferences and strategic cooperation.

3 Experimental design

Subjects are randomly paired. We refer to any two interacting participants as A and B. The A participants are the first movers and the B participants the second movers in the investment game. Each participant receives an initial endowment of 100 Experimental Currency Units (ECU). The amount of initial endowment is common knowledge (see Instructions in Appendix A). Participant A can send any amount (multiple of 10 from 0 to 100) of his or her initial endowment to B. Participant B receives the amount sent by A, multiplied by a factor that we call the multiplier. The multiplier (m) can be either 2 or 4. Each of these two values are equally likely. Only participant B knows the value of m, whereas A knows the probability distribution of m. B can send to A any amount (not necessarily a multiple of 10) taken from his or her initial endowment plus the amount received from A multiplied by 2 or 4. This ends the interaction.

We implement the strategy method introduced by Selten (1967). The decision form differs for participants A and B in the following way: Participant A has to state his or her expectation $E_A(b(a|m))$ about the amount $b(a)$ that participant B will return (for any amount a he or she might send and for each of the two possible multipliers), as well as his or her choice a of the actual amount to be sent. Participant B has to state his or her expectation $E_B(a)$ about the amount A will send, and his or her choice $b(a|m)$ of an amount to return (for every possible amount he or she might receive from A and for the two possible multipliers).

Although the choice of the strategy method is not uncontroversial, we believe that it is appropriate to test trust and reciprocity in a context where lucky trustees may use their informational advantage to mimic the reciprocal behavior of the unlucky ones. Indeed, as Güth et al. (2001) observe, sequential play of the game would likely stress the behavioral relevance of "fairness", and thus one should expect less trust (and reciprocity) in experiments using the strategy method. This method forces subjects to think about the other party's position, and in our design this is made even more explicit by asking participants what they *expect* their partner will do. Furthermore, the low complexity of the game makes emotional responses less likely to alter behavior as compared to the other kinds of strategic interaction.[3]

The monetary payments depend on the amount A has sent, the amount B has returned, and the multiplier. Participant A earns 100 ECUs *minus* the amount sent *plus* the amount returned by B. Participant B earns 100 ECUs plus the amount A has sent, multiplied by 2 or 4, minus the amount returned. The experimental earnings are converted at a rate of 25 ECU to 1 British pound. If a subject's expectation results are correct, the subject earns one extra pound.[4]

4 Experimental procedures

Like Berg et al., we implemented a double blind procedure. Neither the experimenters nor the other participants could identify a decision maker.

The experiment proceeded as follows: First, the subjects entered the room of the experiment and were randomly seated. They read the instructions and filled out a control questionnaire. The objective of the control questionnaire was to check whether the subjects understood the instructions before proceeding with the experiment. After everybody finished reading the questionnaire, participants were requested to draw a card from a bag that contained as many cards as the number of participants in the experi-

[3]See Brandts and Charness (2000) and Schotter et al. (1994) for a further discussion of this topic.

[4]We elicited subject's expectations using a fixed fee. Experimental evidence in eliciting subjects' expectations shows that effort and accuracy in the presence of a flat fee are comparable with the results obtained by implementing more complex procedures, such as Quadratic scoring rule (Sonnemans and Offerman, 2001).

ment. Each card was marked with a code number that they were required to keep secret. One of the cards was marked with the word "monitor." The monitor did not actively participate in the experiment and was the only contact between the experimenters and the subjects during the proceeding of the experiment. He or she just verified that the instructions were followed, distributed the decision forms, collected them, and then supervised the monetary payment procedure. The monitor earned an amount equal to the average earnings of all the other participants. This information was provided to the monitor privately.

The decision forms of A and B participants, once collected, were randomly paired, and the payments were determined according to the amount sent by A, the amount returned by B, and the multiplier, as described above. This was done by first choosing the multiplier randomly, and then checking for B's response to the choice made by the corresponding A. We conducted 3 sessions of the experiment with 11 subjects each (10 subjects plus a monitor). After calculating the payoffs, the experimenters put the money and a description of the calculation into the payment envelopes marked with the code numbers. The monitor then distributed the envelopes to the subjects, who privately checked if the amount was exact and left the room after signing a list with all code numbers and the corresponding payoffs. They signed that they had received money in cash under one of the code numbers printed in the list. In this way their payoff was kept anonymous.

All subjects were first-year undergraduate students at the University of York, and they had not previously participated in economics experiments. Sessions lasted approximately one hour.

5 Results

The data collected consist of the amounts a that A participants want to send, the amounts $b(a)$ that B participants want to return for each feasible value a, the A participants' expectations about the amount $b(a)$, and the amount a that B participants expect to receive from their counterparts. The analysis of the results is divided into two parts: choice and expectations.

5.1 Choice

The results of the experiment strongly reject Hypothesis 1. Figure 1 shows that only one subject (in pair 15) sent zero to his or her counterpart, and only three subjects (in pairs 7, 12, and 14) returned zero to the first mover. The average amount sent was 38 ECUs (with a standard deviation of 24.84); the average amount returned was 47.33 ECUs (with a standard deviation of 42.14).

Figure 2 reports the box plots of the amounts sent by A and the paybacks by B. The two medians (represented in the box plot by the solid lines) are very close (two-sided Wilcoxon rank-sum test, $r = -0.4795$, p-value$=$ 0.6316, i.e., the two medians are not significantly different from each other.) There is more dispersion in the amount of payback than the amount sent. This is explained in part by the fact that B can send any amount, not only multiples of 10, to A, and in part by the increase of the feasible range due to the multiplier.

Figures 3 and 4 show the amount returned by B as a function of the amount received from A when the multiplier was 2 or 4, respectively. These two figures exhibit the same trend, namely, an increase of payback with respect to an increase of amount received. The Kolmogorov-Smirnov goodness-of-fit tests (K-S) comparing the samples of less than 50 ECUs sent with the ones equal to or greater than 50 ECUs sent, reject the hypothesis of same distribution of both levels of the multiplier (for m=2, K-S=1, p-value=0.0079; and for m=4, K-S=1, p-value=0.0079). There is a significant difference in payback when trust is higher (the amounts sent and returned are positively correlated), which is in support of Hypothesis 3. On the other hand, there is no significant difference between the amount of payback for the two multipliers when the amount sent is less than 50 ECUs (K-S =0.4, p-value=0.873), but there is a significant difference between the amount of payback for the two levels of multipliers when the amount sent is 50 ECUs or greater (K-S = 0.83, p-value = 0.026). In the last case, the paybacks for $m = 4$ are higher than paybacks for $m = 2$. Another way to look at this difference is by comparing the difference between $b(a|m = 2)$ and $b(a|m = 4)$ for all values of a greater than zero. The Wilcoxon rank-sum test in this case rejects the null hypothesis of no difference between both return values (r = 4.5966, p-value = 0). These results suggest that the second movers do not take full advantage of their information about the effective value of the multiplier (Hypothesis 4 is unconfirmed); and that the choice on payback is sensitive to the amount of trust and to the total return. However, Figures 3 and 4 show that behavior is consistent with an equal split of the pie only if the multiplier is $m = 2$, but not if $m = 4$ (in the former case, the median payback is very close to the equal-split line, while in the latter case the median payback is clearly below that line.)

Table 1 presents two contingency tables, one for the amounts sent and one for the amounts returned. Both tables compare our results with those of Berg et al. (1995). For the amount sent (contingency table 1), the results indicate no difference between our experiments and those of Berg et al.: Fisher's exact test cannot reject the hypothesis of independence between the rows (Berg et al.; Coricelli et al.) and the columns (category 1: $a = 0$; category 2: $a > 0$, where a is the amount sent). Regarding the amounts returned (contingency table 2), there is a significant difference between our results and the ones of Berg et al. In our experiment, the second movers engage more often in reciprocal behavior, i.e., the number of subjects that return more than the amount that the first mover sent is significantly higher in our experiment, with Fisher's exact test rejecting the hypothesis of independence between the rows (Berg et al., Coricelli et al.) and the columns (category 1: $a > 0$ and $b \geq a$; category 2: $a > 0$ and $b < a$; where b is the amount returned). In our experiment, only 3 out of 14 second movers that received a positive amount returned less than the amount sent to them by the first mover.

5.2 Expectations

Figure 5 indicates that the expectations of the second movers about the amount they would receive from the first movers were very close to the actual amounts (two-sided Wilcoxon rank-sum test, r=0.86, p-value=0.938, i.e., we cannot reject the hypothesis of equal means).

A's expectations about the amount they would receive back for every possible amount they could choose and for both possible values of the multiplier are shown in Figure 6 ($m = 2$) and Figure 7 ($m = 4$). The payback expectation increases with the amount they might send to B. Indeed, the Kolmogorov-Smirnov goodness-of-fit tests comparing the samples of payback expectations for possible amounts sent of less than 50 ECUs and amounts sent of 50 ECUs or more, reject the hypothesis that both samples have the same distribution (K-S =1, p-value=0.0079) for both levels of the multiplier ($m = 2$, and $m = 4$).

On the other hand, there is no significant difference between the expectations of payback for the two multipliers. We cannot reject the hypothesis that the distributions for $m = 2$ and $m = 4$ are the same in absolute terms (K-S =0.455, p-value=0.211). Therefore, the first movers expect a defecting behavior from the second movers, meaning that they expect the second mover to exploit their private information on the effective value of the multiplier.

Table 2 reports ordered probit regression estimates of the amount sent as a function of payback expectation. Similarly, table 3 reports the ordered probit regression of the amount returned on the difference between the amount received and the amount expected from the first mover. In both tables, the estimated parameters are positive and significantly greater than zero (Hypothesis 2 is confirmed).

6 Concluding remarks

The results of our experiment strongly reject the "standard" hypotheses, i.e., our data are inconsistent with the self-regarding preference model. The introduction of asymmetric information in the investment game does not reduce the amounts sent and returned when compared with a previous experimental study of the investment game (with complete information). Moreover, average payback levels increase with the average amount sent. The second movers did not fully exploit their informational advantage regarding the value of the multiplier, even though paybacks tend to fall below "equal split" of the surplus as the multiplier increases. The data on expectations show a remarkable ability of the subjects to predict other subjects' behaviors. The first movers expected an increasing amount of payback for an increasing amount of money sent. The second movers guessed (on average) correctly the amount they would receive.

Decisions and expectations in our experiment deviate from the standard model of self-regarding preference and rationality. Our experimental data are consistent with a model based on subjects' beliefs about the intentionality of the other players' actions (see Rabin, 1993). The first movers' choices are functions of their expectations about the second movers' payback. The second movers' choices depend on the difference between the amount the first movers have sent them and their expectations about this amount.

Our experimental setting allows us to distinguish trust from other motives that may affect the first movers' sending behavior. Indeed, we can measure the amount of trust as the amount sent by a subject expecting a greater amount in payback. This procedure (eliciting payback expectation)[5] solves the critique raised by Cox (2001)[6] about the impossibility of distinguishing between trust and altruism as determinants of the first movers' behavior in the investment game of Berg et al.

[5]The first mover has to express his or her expectation about the amount the second mover will return for any amount he or she might send.

[6]Cox (2001) introduced a "triadic" design in order to distinguish between different motives of reciprocal behavior.

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