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Trusting behavior in a repeated investment game

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Abstract

We compare a seven period repeated investment game to the one-shot investment game. On an average, in the repeated game, player A (the "trustor") sends more and player B (the "trustee") returns a larger percentage than in the one-shot game. Both the amount sent and the percentage returned increase up to period 5 and drop sharply thereafter. The "reciprocity hypothesis" for B players' behavior is compatible with the first five periods, but in the two end periods, most B players behaved strategically by not returning. The "reciprocity hypothesis" for A players' behavior is compatible for all periods of the game.

JEL classification: C72; C91; D63

Keywords: Investment game; Trust; Reciprocity; Repetition

1. Introduction

Trust, like norms and other codes of behavior, plays an important role in social and economic interactions. Recent empirical studies by La Porta et al. (1997) and Knack and Keefer (1997) showed that trust affects various economic and social performance indicators. However, these studies rely on a measure of trust derived from survey data, a fact that has been strongly criticized. For instance, Gleaser et al. (2000) show that people who respond

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positively to the trust question[1] of the General Society Survey do not necessarily send more money in an experimental game of trust. In experimental games of trust, subjects have to make commitments for real amounts of money. Since trusting behavior in real life also involves commitments, behavior observed in experimental games is more likely to represent trusting behavior than answers to hypothetical questions.

Our experimental investigation relies on the investment game, introduced by Berg et al. (1995), which provides a nice environment for observing trusting behavior in the lab. Berg et al. found strong evidence of trusting behavior in their experiment, a fact confirmed by other experimental studies (e.g. Güth et al., 1997; Ortmann et al., 2000; Gneezy et al., 2000).

In the investment game two players (A and B) are each endowed with 10 experimental currency units. Player A can send any integer amount S, with $0 \leq S \leq 10$, to an anonymous player B. The amount sent is tripled by the experimenter, and player B can decide to return any amount R to player A, with $0 \leq R \leq 3S$. For rational and selfish players, the investment game has a unique subgame perfect equilibrium, characterized by $S = R = 0$ for which each player ends up with his endowment. On the other hand, positive investment by player A increases the players joint payoff, which is equal to $20 + 2S$ and maximal for $S = 10$.

In this paper we are interested in the evolution of trust when subjects interact repeatedly. Our experimental design is based on a finitely repeated investment game with matched player pairs. By repeating the game, trust and reciprocity can evolve over time. More precisely, repetition may create a context in which trust can emerge as the outcome of a sustained social relationship in a controlled environment. This context adds a mechanism that eventually favors trusting behavior beyond the propensity to trust unknown people. We compare the results of the repeated investment game to the results of the one-shot investment game: the one-shot investment game captures pre-existing trust, and the repeated investment game allows for reinforcement or breakdown of trusting behavior. We observe that the amount sent increases over time, that the proportion returned increases, and that there is a sharp end effect characterized by low return followed by low sending.

In the repeated investment game, the level of trust in period t will be influenced by history and past experiences of trusting behavior, as well as by subjects' expectations. The amount sent by player A can evolve as a reaction to the amounts returned by player B in earlier periods. This contrasts with the one-shot investment game, where player B does not need to care for player A's reaction. Taking into account player A's future reaction might for example lead player B in period 1 to return a larger amount than sent by player A, intending to induce player A to increase the amount sent in the next period. Player A will do so if he believes that player B will return at least the same proportion as in period 1, but why should player B act in such a way in period 1?

Two possible explanations can be provided: reputation building and reciprocity. The reputation hypothesis assumes that player A is uncertain about player B's type. For example, one can think of player B being a "reciprocal type" or a "selfish type". If player B is selfish he will try to hide his type so that player A does not stop sending. Player B will return at least the amount sent by player A with a high probability in the early rounds of the repeated game. By acting in this way, player B takes advantage of player A's state of uncertainty,

[1] This question asks which of two alternatives is preferable in the sentence: "Generally speaking would you say that most people can be trusted or that you cannot be too careful in dealing with people"?

but as the game proceeds towards the end round, the probability that player B keeps the amount received by player A approaches unity. Following earlier experiments (Camerer and Weigelt, 1988; Neral and Ochs, 1992; Brandts and Figueras, 2003), Cochard et al. (2002) investigated the sequential equilibrium concept (Kreps and Wilson, 1982), on the basis of a restricted investment game for the data reported in their paper. They found that the sequential equilibrium does not provide an adequate framework for organizing the data, except for the end effect.[2] Furthermore, there are many possibilities that define types in the investment game.

Therefore we investigate an alternative explanation based on the reciprocity hypothesis (Fehr and Gächter, 1998). The reciprocity assumption for player B's behavior states that the proportion returned by player B is positively related to the amount sent by player A. Any increase in the amount sent is rewarded by player B by returning a larger share of the generated surplus, and any decrease in the amount sent is punished by player B by returning a lower share of the generated surplus. Note that rewards and punishments are expressed in relative terms since player B could not use absolute rewards and punishment in the game. The reciprocity assumption for player A's behavior states that the amount sent by player A in the current period is positively related to the proportion returned by player B in the previous period.

Section 2 presents the experimental design, and Section 3 our main findings. Section 4 discusses the predictability of the reciprocity hypothesis, and Section 5 concludes.

2. Experimental design

Sixteen pairs of subjects who participated in the repeated experimental investment game were split into two sessions of eight pairs, and 20 pairs of subjects who participated in the one-shot experimental investment game were split into two sessions of 10 pairs. For each session, subjects were randomly selected in a subject pool of volunteers (about 600 subjects) and informed individually that they were invited to participate in an experiment. We managed to get very heterogeneous samples with subjects of both sexes, of ages ranging from 17 to 30, from different universities (scientific or not).

Upon arriving at the experimental lab, each subject was randomly assigned either to room A or B, which defined his role for the rest of the experiment (players A or B). For the one-shot game, we used a double-blind procedure similar to Berg et al. For the repeated game the double-blind procedure required some slight adaptation as explained below. For both games, the double-blind procedure guarantees that subject's decisions are completely anonymous with respect to the other subjects, the experimenter and the monitor and, therefore, that they are not influenced by other persons. For the repeated game, each subject in room A was randomly paired with a subject in room B. Subject pairs were informed that they would play the investment game for seven periods. For practical reasons, we could not use real money for the repeated game. Instead, each subject pair communicated through envelopes

[2] Anderhub et al. (2002) found that if subjects can learn through the repetition of the repeated trust game, the reputation hypothesis does fairly well organize the data. However, their trust game differs in many respects from the investment game chosen for our experiment.

Table 1
Summary data for the one-shot and the repeated investment game (averages)

	Repeated	One-shot
Amount sent	7.47	5.00
Percentage returned[a]	56.14	38.21
Payoff of player A	15.20	10.65
Payoff of player B	19.74	19.35
Joint payoff	34.95	30.00

[a] Calculated only for positive sendings.

with code numbers. At the end of the experiment, the subjects received their cash-payoff in local currency in the same envelopes. For comparative purposes the same procedure was applied for the one-shot game. In each period of the repeated game and at the beginning of the one-shot game, each subject was given an endowment of 10 experimental currency units (ECU). The conversion rate was equal to 1.20 FF per ECU for the repeated investment game and 8.40 FF per ECU for the one-shot game. These conversion rates was chosen in order to keep incentives comparable across treatments, assuming subgame perfection[3] (i.e., player A sends zero and player B returns zero if he receives a positive amount).[4]

3. Results

In this section we provide a summary of our main results. The complete data set for the repeated game is reported in Appendix A.

Result 1. On average, in the repeated game player A sends more and player B returns a larger percentage than in the one-shot investment game.

In the repeated investment game the overall average level of investment is equal to 7.5, and the overall average percentage returned (for positive amounts sent) is equal to 56 percent. These amounts are significantly larger than zero (binomial test, 1 percent level).[5] This of course also implies that the average gain is significantly larger than 10 for both types of players, 15.2 for A players and 19.7 for B players. Only one player A earned slightly less than 10 units (9.82). Investment was therefore advantageous for both types of players, with an overall average joint payoff equal to 34.95, significantly larger than predicted and close to its maximum possible value. As shown in Table 1, these figures are larger than the corresponding figures for the one-shot game, and all differences between the two games

[3] For the repeated investment game, the “sequential equilibrium” concept introduced by Kreps and Wilson would be more meaningful. However, depending on how one defines types for this game, there are several possibilities for defining a sequential equilibrium.

[4] The instructions of the experiment are available from the authors upon request.

[5] All nonparametric tests are performed using strictly independent data. For the repeated game, we have 16 independent observations, each one corresponding to an average over the seven periods for each pair of subjects.

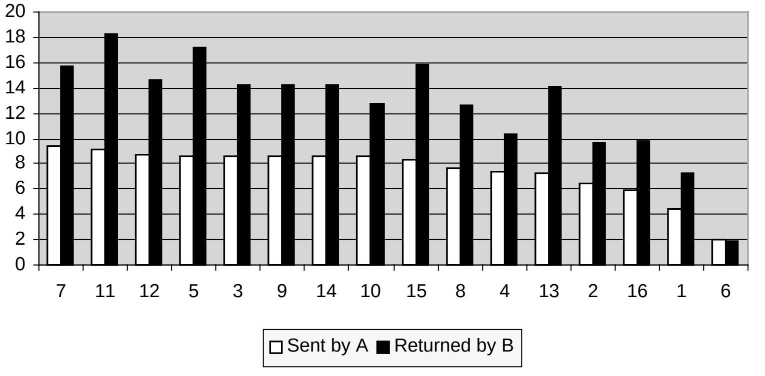

Fig. 1. Average amount sent and returned per player pair in the repeated investment game (sorted by amount sent and amount returned).

are significant at the 5 percent level (one-sided, Mann–Whitney). This is summarized in Table 1.

Let us define the *payoff ratio* as player A's payoff in percentage terms of player B's payoff.

Result 2. The payoff ratio is larger in the first six periods of the repeated investment game than in the one-shot game. In the last period it is equal to the average payoff ratio of the one-shot game.

The average payoff ratio is equal to 86 percent for the repeated investment game and 63 percent for the one-shot game. The difference is significant at the 5 percent level (Mann–Whitney, one-sided). In the repeated investment game, the average payoff ratio first increases, starting at 90 percent in period 1 and reaching 98 percent in period 5, and declines sharply in period 6 ending at 59 percent in period 7, below the corresponding value for the one-shot game. The payoff ratio is significantly larger in the repeated game for periods 1–6 than in the one-shot game (Mann–Whitney, one-sided, 1 percent level), but not for period 7.

Fig. 1 shows for each player pair on the horizontal axis, the amount sent and the amount returned averaged over the seven periods of the repeated game. As can be seen, player B returned at least the amount sent by player A (except for player pair 6). Therefore, for the whole repeated game, trust was not misplaced, since in all player pairs and in a majority of periods, player B returned more than the amount sent. Fig. 2 shows for each player pair the amount sent and the amount returned in the one-shot game. Even though most of the B players returned more than the amount sent by player A, one-third of them returned less than the amount sent.

Result 3. In the last period of the repeated game the average amount sent is not different from the one-shot game, but the percentage returned is lower. Furthermore, most A players either sent their whole endowment or nothing.

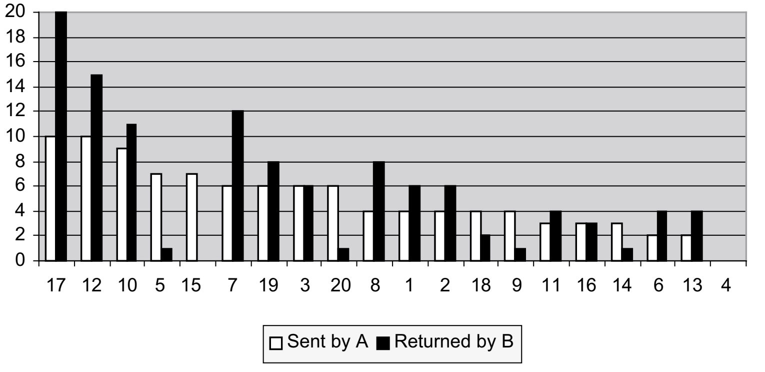

Fig. 2. Amount sent and returned per player pair in the one-shot investment game (sorted by amount sent and amount returned).

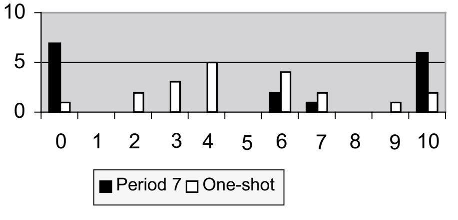

Fig. 3. Comparison of the frequency distributions of amount sent for the one-shot game and the last period of the repeated game.

In period 7, the average level of investment is very close to the level observed in the one-shot game, but the percentage returned is much lower (18 percent compared to 38 percent). This difference is not significant, but the payoff of player A is significantly larger in the one-shot game than in the last period of the repeated game (Mann–Whitney, one-sided, 5 percent). About half of the A players no longer sent in period 7. Among those, four experienced a null return by player B in period 6. The payoffs of both players are not significantly different from 10 (six of the A players and seven of the B players earned exactly 10 in period 7). Most B players kept the whole amount received. In three of the player pairs (pairs 1, 11 and 16) in which player A still sent a positive amount, player B returned a larger positive amount.

Fig. 3 compares the frequency distributions of amounts sent in period 7 with the amounts sent in the one-shot game. In the one-shot game the distribution has a single mode at 4. In contrast, in period 7 we observe two modes on extreme sendings: 44 percent of the A players send 0 while 38 percent send 10. In contrast to the one-shot game where the amounts sent are spread all over the strategy set, they are concentrated on extreme values in the last period of the repeated game. While the difference appears clearly in Fig. 3, a two-sided Kolmogorov–Smirnov test does not reject the null hypothesis at the 5 percent level.[6] As a consequence 44 percent of the B players earned 10 in period 7 and 19 percent earned 40.

[6] The null hypothesis is rejected only at the 10% level.

Table 2
Percentage of extreme sendings and equitable returns

Period	Amount sent		Percentage returned[a]	
	0	10	0	≥2/3
1	0	44	0	62
2	0	37	0	75
3	0	50	0	75
4	6	50	0	80
5	6	62	0	93
6	0	69	31	56
7	44	38	56	11

[a] Calculated only for positive sendings.

Result 4. The average amount sent increases until period 6 and the average payoff ratio until period 5. Both indicators decline sharply thereafter.

Table 2 provides details about extreme choices period by period. The number of A players who send their whole endowment increases until period 6 and collapses in period 7 (see Appendix A). The amount sent in all player pairs increases until period 6. We also observe that the number of B players who return at least 2/3 of the amount received increases until period 5, where all B players except 1 return at least 2/3. Therefore, the average payoff ratio reaches its maximum in period 5. Several B players stop returning in period 6, leading a decrease in the payoff ratio and inducing the corresponding A players to stop sending in the last period. Half of the B players who still return in period 6 do not return in period 7 whenever player A keeps on sending (only four of the B players returned a positive amount in the last period). There are only three pairs in which the "defection" by player B is anticipated. The behavior of A players also changes, but only in the last period and in a less systematic way. Still many A players send positive amounts in period 7.

Table 3 draws a distinction between the last period of the repeated game and the earlier periods. For the six initial periods, with the exception of player B's payoff, all the indicators are at a higher level compared to the overall repeated game. The percentage returned by player B and player A's payoff are significantly larger than in the last period of the repeated game (Wilcoxon sign rank test, one-sided, 5 percent), but the amounts sent by A players and the payoffs of B players are not significantly different for periods 1–6 and 7, implying that the total payoff of the player pairs do not differ either.

Table 3
Comparison of averages of the first six periods and period 7

	Periods 1–6	Period 7
Amount sent	7.90	4.94
Percentage returned	59.74	18.47[a]
Payoff of player A	16.42	7.94
Payoff of player B	19.38	21.94
Total payoff	35.79	29.87

[a] For period 7, there are only nine observations for which the amount sent is positive.

4. The reciprocity hypothesis

Reciprocal behavior assumes that each player relies on "rewards" and "punishments" to react to the observed action of the other player. We assume that in periods $t = 1, \dots, 7$, player B reacts to an increase (decrease) of the amount sent (S_t) by increasing (decreasing) the percentage returned ($R_t/3S_t$). For periods $t = 2, \dots, 7$, player A reacts to an increase (decrease) in $R_{t-1}/3S_{t-1}$ by increasing (decreasing) S_t. Taken together we call these two behavioral assumptions the *reciprocity hypothesis*.

According to the reciprocity hypothesis, the percentage returned by player B increases with the amount sent by player A: $R/3S = f(S)$, $f'(S) > 0$, $S \neq 0$. Assuming a linear specification, we have $R/3S = \bar{\beta}_1 + \bar{\beta}_2 S$. To avoid dividing by zero we get $R = 3\bar{\beta}_1 S + 3\bar{\beta}_2 S^2$ or $R = \beta_1 S + \beta_2 S^2$, where $\beta_1 = 3\bar{\beta}_1$ and $\beta_2 = 3\bar{\beta}_2$. The reciprocity hypothesis implies that β_2 is positive and significantly different from zero.

Since R_{it}, the observed amount returned, is bounded by 0 and $3S_{it}$, we use a double censored specification:

$$R_{it} = \begin{cases} 0 & \text{if } R^*_{it} \leq 0 \\ R^*_{it} & \text{if } 0 < R^*_{it} < 3S_{it} \\ 3S_{it} & \text{if } R^*_{it} \geq 3S_{it} \end{cases}$$

We assume that

$$R^*_{it} = \alpha + \beta_1 S_{it} + \beta_2 S^2_{it} + \gamma_2 P_2 + \cdots + \gamma_7 P_7 + u_{it}$$

where R^*_{it} is the true (unobservable) amount returned by player B, and S_{it} the amount sent by player A in pair i for period t. P_t are dummy variables for the period of play (period 1 being taken as the reference period) and u_{it} the error term. When $S_{it} = 0$, we do not know whether the observation is left or right censored. In this case, we may interpret $R^*_{it} < 0$, as if player B would like to "punish" player A for not sending. We shall refer to that case as the "*punishment hypothesis*". If $R^*_{it} > 0$, player B's attitude can be interpreted as altruistic since he would like to increase player A's payoff without any compensation. We shall refer to that case as the "*altruistic hypothesis*".

Assume that $u_{it} = \mu_i + \varepsilon_{it}$, where μ_i is an effect specific to pair i, and ε_{it} is an idiosyncratic error term ($\varepsilon_{it} \mid X_{it} \sim N(0, \sigma^2_\varepsilon)$), where X_{it} is the vector of regressors). We may assume μ_i as fixed effects (FE) or random effects (RE), $\mu_i \mid X_{it} \sim N(0, \sigma^2_\mu)$. The RE model is estimated by the maximum likelihood (ML) method. The FE model can be estimated by ML as in the RE case or by an iterative ML method proposed by Heckman and MaCurdy (1980).[7] For our data sample, the two approaches give similar results.

A critical hypothesis for the consistency of the RE estimator is that μ_i are uncorrelated with the regressors ($E(\mu_i \mid X_{it}) = 0$). To check this hypothesis, we perform a Hausman test

[7] See also Maddala (1987). The iterative method consists in estimating separately and iteratively the coefficients of regressors and FE by ML.

Table 4
Estimation results for the regression of R_{it} on S_{it} for the repeated game

Variable	Altruistic hypothesis		Punishment hypothesis	
	Coefficient	S.E.	Coefficient	S.E.
S_{it}	−1.148	0.832	3.516[a]	0.958
S_{it}^2	0.194[a]	0.066	−0.119	0.072
P_2	1.556	1.860	0.567	1.718
P_3	1.830	1.872	0.355	1.734
P_4	1.973	1.899	0.569	1.740
P_5	2.280	1.917	0.809	1.755
P_6	−4.505[a]	1.904	−5.570[a]	1.760
P_7	−8.525[a]	2.101	−13.224[a]	2.177
Intercept	9.401[a]	2.575	−4.755	2.944
Log-likelihood	−303.699		−291.654	
Wald's statistic[b]	109.22[a]		159.08[a]	

Number of observations: 112.

[a] Indicates significance at the 5 percent level.

[b] Wald's test is used to compare the constrained model (the model with only the intercept) and the current model. Its statistic follows a $\chi^2_{(8)}$.

that compares the RE model with the FE model.[8] In computing the statistic, we use the estimates obtained by iterative ML for the FE model. The test statistic is 8.60 and 21.23 for the altruistic and the punishment hypotheses, respectively. Comparing these values with $\chi^2_{(8)} = 15.51$ at the 5 percent level, we conclude that the RE model is preferable in the case of the altruistic hypothesis while the FE model is preferable in the case of the punishment hypothesis.

Now we turn to compare these models with the pooled model (without pair effects) by using a likelihood ratio (LR) test. First, considering the altruistic hypothesis, the null is H_0: $\sigma_\mu = 0$ (the pooled model) and the alternative is H_1: $\sigma_\mu > 0$ (the RE model). The LR statistic is approximately $0 < \chi^2_{(1)} = 3.84$ at the 5 percent level, then we cannot reject the pooled model against the RE model. Second, in the case of the punishment hypothesis, the null is H_0: $\mu_i = 0, \forall i$ (the pooled model) and the alternative is H_1: $\mu_i \neq 0$ for at least one i (the FE model). The LR statistic is $17.87 < \chi^2_{(15)} = 24.99$ at the 5 percent level, implying that the pooled model is preferred to the FE model. As a result, we observe that the pooled model (without pair effect) is preferable in both the altruistic and the punishment hypotheses. Estimation results of the pooled model for the repeated game are presented in Table 4. Results of the one-shot game are reported in Table 5.

As indicated in Tables 4 and 5, our regressions are significant for both hypotheses (the Wald statistic is significant at the 5 percent level). For the repeated game, there is a positive influence of the amount sent on the amount returned under both hypotheses. We also observe a strong and significant end effect under both hypotheses (the effects of P_6 and P_7

[8] One computational difficulty is that the Hausman statistic may be negative. In this case, we use a correction as by Lee (1996, pp. 20–21) in order to obtain a positive value.

Table 5
Estimation results for the one-shot game

Variable	Altruistic hypothesis		Punishment hypothesis	
	Coefficient	S.E.	Coefficient	S.E.
S_{it}	−3.051	1.690	−0.348	1.319
S_{it}^2	0.369[a]	0.139	0.161	0.114
Intercept	9.552[a]	4.497	2.058	3.376
Log-likelihood	−49.849		−52.284	
Wald's statistic[b]	23.14[a]		20.10[a]	

Number of observations: 20.
[a] Indicates significance at the 5 percent level.
[b] Wald's test is used to compare the constrained model (the model with only the intercept) and the current model. Its statistic follows a $\chi^2_{(2)}$.

Table 6
Estimation results for the regression of S_{it} on $R_{i,t-1}/3S_{i,t-1}$ for the repeated game

Variable	Coefficient	S.E.
$R_{i,t-1}/3S_{i,t-1}$	18.237[a]	3.556
P_3	0.363	1.647
P_4	0.257	1.647
P_5	1.879	1.802
P_6	2.940	1.880
P_7	−1.392	1.697
Intercept	−1.837	2.412
Log-likelihood	−140.008	
Wald's statistic[b]	40.56[a]	

Number of observations: 94.
[a] Indicates significance at the 5 percent level.
[b] Wald's test is used to compare the constrained model (the model with only the intercept) and the current model. Its statistic follows a $\chi^2_{(6)}$.

are negative). In both the repeated and the one-shot games, the behavior of player B is compatible with the prediction of the reciprocity assumption ($\beta_2 > 0$) only under the altruistic hypothesis. According to the log-likelihood values, the punishment hypothesis provides better statistical results in the repeated game whereas the altruistic hypothesis does in the one-shot game.

We carry out a similar analysis for the behavior of player A using a double censored model for the relationship between S_{it} and $R_{it-1}/3S_{it-1}$.[9] Test results (Hausman test and LR test) show that the RE model provides a better approximation of the data than the FE and pooled models. Estimation results of the RE model are reported in Table 6. The regression

[9] As the dependent variable, S_{it}, is censored between 0 and 10, the distinction between the altruistic and punishment hypothesis is now irrelevant. Two observations for which $S_{it-1} = 0$ had to be removed for the estimation to avoid division by zero.

is also significant (the Wald statistic is significant at the 5 percent level). $R_{it-1}/3S_{it-1}$ has a significant and positive effect on S_{it}. Trusting by A players was therefore reinforced when they received larger shares from B players, in accordance with the reciprocity assumption. None of the period dummies P_3–P_7 has a significant impact on the amount sent. The absence of a significant end effect for A players is therefore a further indication that amounts sent are essentially attributable to trusting behavior. The fact that A players did not change their behavior in the last period indicates that their expectations were mainly based on their history of amounts returned in previous period, leading almost all of them to trust even in the last period.

5. Conclusion

We designed an experiment to study the behavior of subjects in a repeated investment game. By repeating the investment game with the same pair of players, our primary purpose was to try to separate “pre-existing motives” that could lead player A to send money to player B from motives derived by the repeated interaction between the players. A second objective was to compare subjects’ decisions in the repeated investment game with the subjects’ decisions in the one-shot investment game. Repetition can induce more cooperation among players and, therefore, more trust and more reciprocity. In particular, we compared the outcome of the last period of the repeated game with the outcome of the one-shot game.

Our data show that on average the amount sent and the percentage returned increase with repetition. We estimated a double censored model which partly supports the reciprocity hypothesis. However, the end effect seems to indicate that B players returned fair amounts in early periods for strategic purposes: reinforcing player A’s trust in the fairness and reciprocity of player B. By playing fair, player B could build a reputation of fairness for player A. Either B players acted in a purely selfish way or changed their behavior over time, starting with a reciprocal behavior and ending playing selfish by discovering that player A became more and more confident. A plausible reason why B players changed their behavior over time is “erosion of reciprocity”. B players start behaving reciprocally, but as periods elapse they might feel that they have been reciprocal enough in earlier periods to allow themselves to act more selfishly, which is like a kind of “warm-glow reciprocity”.

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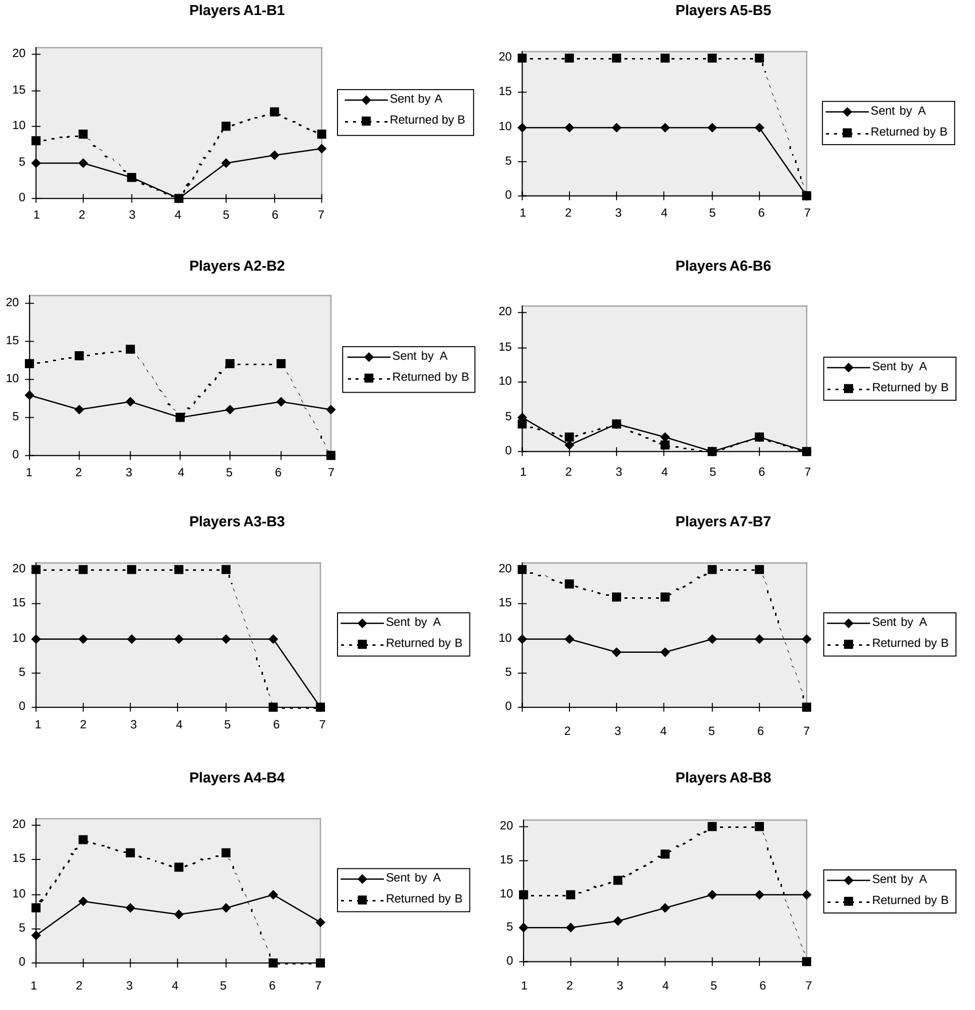
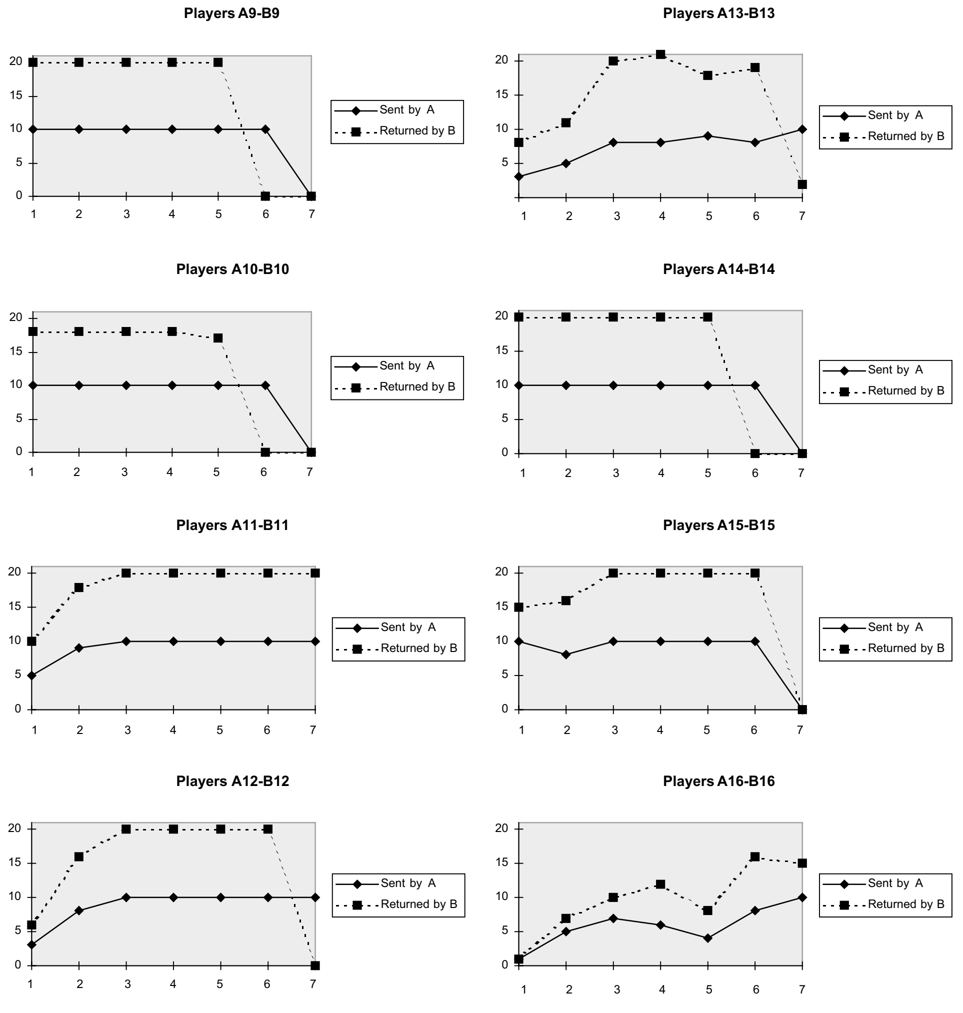
Appendix A

Amounts sent and amounts returned per period and per player pair in the repeated investment game





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