Money and reciprocity

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Abstract:

Based on an experimental analysis of a simple monetary economy we argue that a monetary system is more stable than one would expect from models based solely on individual rationality. We show that positive reciprocity stabilizes the monetary system, provided every participant considers accepting money as a reasonable option. If however some participants notoriously refuse to accept money then due to negative reciprocity their behavior will eventually induce a break down of the monetary system.

JEL classification: C73, C91, C92, E40, E41, E42

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Introduction

One of the fundamental problems in economics is to understand under which conditions a monetary equilibrium is obtained in which an intrinsically useless object like fiat money has positive value in exchange for commodities. Since monetary equilibria are Pareto superior to non-monetary equilibria, economic policy makers need understand which shifts in the exogenous conditions of the economy may lead to a break down of the monetary system, i.e. may lead an economy from its monetary equilibrium to a non-monetary equilibrium in which money has no positive value in exchange of commodities..

To solve this problem, economic theorists looked into game theoretic foundations of money. Starting from the seminal papers of Kiyotaki and Wright (1989, 1991, 1993) an impressive literature developed in which markets are no longer considered to be well organized but traders meet randomly in pairs, see also Boldrin, Kiyotaki and Wright (1993), Trejos and Wright (1993) and Wright (1995). This literature has shown that in a decentralized economy a positive value of money can emerge naturally as a Nash-equilibrium. In particular no monetary authority is needed to back money. The stability of the monetary system is thus solely based the assumption of common knowledge of individual rationality. It is based on the belief that the other trading partners accept money which itself makes accepting money the best choice of every participant. The participants switch to the non-monetary Nash-equilibrium if the exogenous uncertainty about finding a trading partner is too high to sustain accepting money as the best response to itself. This uncertainty is for example modeled by a break-off probability, which determines whether the game is continued to the next round.

The purpose of this paper is to argue that individual rationality – understood as maximization of an objective function that depends on the actions of the other players but that ignores the payoffs of the other players – is not sufficient to understand the stability of a monetary system. As has been argued elsewhere (see for example Rabin (1993), Bolton and Ockenfels (2000), Fehr and Gächter (1998), Charness and Rabin (2000), Cox (2002)), individual behavior is often motivated by *reciprocity*. Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Falk and Fischbacher (1999)) for example, have shown that taking also into account the effect of inequity aversion, will give a much better model to predict individual behavior. Many experimental findings support this result (for a review see Fehr and Schmidt (2001)). Other authors use different preferences or intentions. In this paper we argue that due to *positive reciprocity* a monetary system is more stable than individual rationality would suggest, provided every participant considers accepting money as a reasonable option. That is to say, even if for the given break off probability individual rationality would imply not to accept money reciprocal behavior will still lead to a monetary equilibrium. If however some participants notoriously refuse to accept money then due to *negative reciprocity* their behavior will eventually induce a break down of the monetary system.

Since the point of our paper is to get some first insights into the effects of reciprocity on the stability of monetary systems, we will not start from the most advanced micro-money model developed so far. We rather begin by looking at the most elementary monetary economy in which one indivisible unit of a service can be bought and sold (in an infinite horizon economy with random matching) against one indivisible unit of money. To be more specific, in every period there are two groups of agents. Those endowed with one unit of money and those without any money. Money holders try to buy a service from non-money holders. The latter can decide whether to accept money for the service or whether to reject it. If they accept money then they loose some utility from providing the service but they become money holders in the next period. On the other hand money holders try to give away their money in order to benefit from the service.

A simple argument shows that, as usual, there are two stationary equilibria in this elementary monetary economy: Non-monetary equilibria in which nobody accepts money and monetary equilibria in which some participants accept money. Our reasoning is based on how the occurrence of monetary equilibria depends on discounting. Discounting is enforced by a chance move that determines whether the game is ended in this period or whether it is continued. To get some insight of actual behavior in such an elementary monetary economy we run a series of experiments in which a market is set up with precisely this structure. As a point of reference we also run individual decision experiments in which the probability that money is accepted is given exogenously. In the experiments it turns out that agents tend to accept money in the market experiment even for those discount factors for which they have rejected money in the individual decision situation. Whereas neither strategic behavior nor social conventions can explain this fact it can be derived from positive reciprocity. Agents tend to accept money if they themselves have previously benefited from someone accepting money. It is important to note that in this case money is accepted even though by this choice the expected utility, ignoring the payoffs of others, is decreased, i.e. even though standard rationality would be violated! Moreover, the experiments show that agents tend to reject money if the absolute number of rejections they have faced so far exceeds some trigger value. Note that standard rationality would highlight the importance of the relative frequency of rejections faced so far. We explain this finding by negative reciprocity.

The Kiyotaki-Wright model has been experimentally tested by Duffy and Ochs (1999). Overall it turned out that the market predictions work well. In this paper we will focus on the individual behavior and how interaction in a market changes individual behavior. As often observed market behavior might be as predicted by theory whereas individual behavior is different. For this reason we have chosen a simpler setting and two treatments: one on individual behavior and one on market behavior from which we want to draw our conclusions. As discussed above it will turn out that boundedly rational behavior rather stabilizes a monetary system than it destabilizes it.

The organization of the paper is as follows. In the first part we present a model in the form of a game that represents the considered situation. We also formulate an individual decision problem to compare the effects of the individual decisions with the effects in a market. In the theoretical part we define and characterize stationary equilibria. In the last part we test the theoretical results in an experiment. First it turns out that stationary strategies are indeed played by most participants. Incorporating reciprocity in our model allows us to define asymmetric stationary equilibria including the effect of reciprocity. This then allows us to explain two additional experimental findings. Agents tend to accept money in the market experiment even for those discount factors for which they have rejected money in the individual decision situation and agents tend to reject money if the *absolute* number of rejections they have faced so far exceeds some trigger value.

The Model

We analyze an individual decision making problem (game A) and a market (game B). Game B is the game representing the situation described in the introduction. Game A results from game B by "reducing" game B to an individual decision making problem. For the theoretical and experimental analysis it is instructive to compare the results of game B with the results of A.

The individual decision making situation: Game A

Time is discrete and infinite: t=1,2, … (periods). In every period the decision maker selects her action out of the two possible actions {a,n}. The action "a"(ccept) is interpreted as: provide a service and accept one unit of money for the service. The action "n"(ot) is interpreted as not accepting money and not providing the service. Let c and g be positive constants. Let $u_i()$[1] be the utility function of player i. . $u_i(-c)$ is the utility cost of providing the service and $u_i(g)$ is the utility gain from obtaining the service. If the decision maker i chooses action "a" she receives one unit of money and her payoff in this period is $u_i(-c)$. In the next period she is then endowed with one unit of money which she uses in order to get the benefit $u_i(g)$. If she chooses "n" she does not receive one unit of money and her payoff is 0 and the game ends. Note that money does not provide any utility itself. It is a means to obtaining $u_i(g)$.

See Figure 1 for an illustration. A player can be in two states, A or B, or she can end the game. If she is in state A she makes her choice "a" or "n". If she chooses "n" the game ends. If she chooses "a" she changes to state B, receives one unit of money

[1] We assume a utility function that is time additive, i.e:
$U(x) = \sum_{t=1}^{t} \beta^t \cdot u(x_t)$, with β a discounting rate and $x = (x_1,..,x_t)$. A motivation based on experimental observations will be given later.

and has a payoff of $u_i(-c)$. In this case she automatically changes from state B to state A. At the beginning of the next period she receives the benefit $u_i(g)$ for one unit of money. She can only choose action “p”ay the unit of money for the benefit if she is in state B. Note that introducing not paying the money as a second choice of a player in state B would be weakly dominated because of discounting.

After every period a chance moves determines whether the game is continued or ended. The probability of continuing is β (0 ≤ β ≤ 1). The chance move models the discounting.

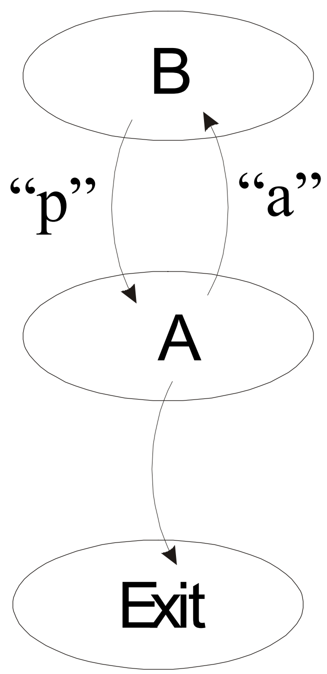

Figure 1: Schematic presentation of the transitions between the groups A and B depending on the choices in the individual optimization problem (game A).

The Market: Game B

We consider the following game. Time is discrete and infinite: t=1,2, … (periods). The players are I={1,2,..,N} with N even.

At the beginning of the first period half of the players are endowed with one unit of money. These players are said to be in group B. The other half of the players does not have money. They are said to be in group A. Initially groups are randomly selected. Every period every player in group A can provide a service which can be offered to group B-players at a price of one unit of money. Every period consists of four stages.

In the first stage the players select their actions. The players who are in group A can select between two actions {a,n} as in game A. The action "a"(ccept) is interpreted as: provide a service and accept one unit of money for the service. The action "n"(ot) is interpreted as not accepting money and not providing the service. The players in group B play "p"(ay) which is interpreted as pay one unit of money and benefit from the service (provided one is matched with some player playing "a"). As in game A, introducing "n" as a second choice for group B-players would be weakly dominated because of discounting.

In the second stage every player of group A is randomly matched with one player of group B. The players are not informed about the name of their partner.

In the third stage the payoffs in this period are determined. $u_i(-c)$ is the cost of providing the service and $u_i(g)$ is the gain of player i from obtaining the service. The per period payoff of the matched pair of players i (in group A) and j (in group B) depends on the chosen actions as given in table 1.

i/j	"p"(ay)
"a"(ccept)	$u_i(-c)$, $u_j(g)$
"n"(ot) accept	0,0

Table 1: Payoff of a matched pair of players.

If player j receives a payoff $u_j(g)$ she changes from group B to A. Correspondingly, player i with whom she is matched gets the payoff $u_i(-c)$ and changes from group A to B. The interpretation is that player j obtains the service and pays one unit of money to player i who provides the service. If no money is accepted both players get a payoff of 0 and do not change groups. This is illustrated in Figure 2.

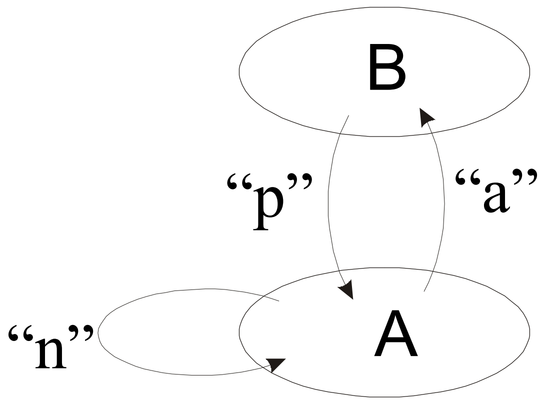

Figure 2: Schematic presentation of the transitions between the groups A and B depending on the choices in the market (game B).

In stage four a chance move determines whether the game is continued or ended. The probability of continuing is β (0≤β≤1). This chance move is interpreted as discounting.

Equilibrium Concepts

The stationary solution of Game A

The expected total continuation payoff $v_i(A)$ of the decision maker from the point of view of state A is:

$$v_i(A) = \max_{n_t, a_t} \{\beta \cdot v_i(A), u_i(-c) + \beta \cdot (u_i(g) + v_i(A))\}.$$

Where the first (second) argument in the maximum operator is obtained for the choice n_i (a_i).

The stationary solution of this decision problem gives the criterion when to choose "n" and when to choose "a".

Choosing action "a" is optimal, if: $0 \leq u_i(-c) + \beta \cdot u_i(g)$.[2]

Choosing action "n" is optimal, if: $0 > u_i(-c) + \beta \cdot u_i(g)$.

An interpretation of this criterion is that the decision maker selects "a" if the expected payoff of paying $u_i(-c)$ in one period and obtaining the payoff $u_i(g)$ with probability β in the next period is higher than or equal to the payoff 0 for action "n". Otherwise she will select action "n". For a given decision problem with fixed β according to this solution a decision maker will in every period select either "n" or either "a" depending on the inequality above. Every player can be described by a cut-off value $\overline{\beta_i}$ for which she is indifferent between the two actions. If $\beta \geq \overline{\beta_i}$ she chooses action "a" and action "n" otherwise. On normalizing $u_i(0)=0$, the utility difference $u_i(g)-u_i(-c)$ determines $\overline{\beta_i}$. This utility difference may then be interpreted as the risk aversion of player i.

The Stationary equilibrium of Game B

A stationary equilibrium is a Nash equilibrium with time invariant choices of the players. The best-reply condition is given by the Bellman equations. In the model of this paper the interaction of the players is incorporated in the definition of the

[2] The tie breaking rule arbitrarily decides if a player is indifferent that she chooses action "a". It is one possibility to deal with the indifference. We will treat the other rules (for Game B) in the same way.

equilibrium by a parameter $ß_i$ which is the individual discounting rate of player i. This rate includes the exogenous discounting ß and the further discounting caused by the decisions of the other players who do not choose action “a”.

<u>Definition</u>

A stationary equilibrium consists of the individual discounting rate $ß_i^* \in [0,1]$ of player i and the reaction functions

R_i^*: [0,1] x [group] → {a,n,p} with group being A or B .

Where for all i $\in \{1,..,N\}$:

i) R_i^* is optimal given $ß_i^*$:

R_i^* fulfills the Bellman equations:

$$v_i(A) = \max_{n,a}\{0 + \beta_i^* \cdot v_i(A), 0 + u_i(-c) + \beta_i^* \cdot v_i(B)\}$$

$$v_i(B) = u_i(g) + \beta^*{}_i \cdot v_i(A)$$

ii) $ß_i^*$ is consistent with the decisions of the other players.

$$\text{let } \Delta_k = \begin{cases} 1, \text{if player k selects "n"} \\ 0, \text{if player k selects "a"} \end{cases} \quad \text{and} \quad n_i = \sum_{\substack{k=1 \\ i \neq k}}^{N} \Delta_k$$

$$\beta_i^* = \max(0, 1 - \frac{n_i}{N/2}) \cdot \beta$$

The condition ii) states that the individual discounting of every player consists of the discounting rate and the decisions of the other players which reduce the discounting. In equilibrium the individual discounting rates of all players have to be “consistent”. The players selecting action “n” in equilibrium stay in group A and the others switch between groups giving them their expected payoff. However, these players do not switch every period for sure because of the matching. This effect is incorporated in the individual discounting.

Solution of the Bellman equations

First we look at the case in which it is optimal to choose action „a“. The solution of the Bellman equations is straight forward and gives the result

$$v_i(A)^* = \frac{\beta_i^* \cdot u_i(g) + u_i(-c)}{1 - \beta_i^{*2}}$$

and

$$v_i(B)^* = \frac{\beta_i^* \cdot u_i(-c) + u_i(g)}{1 - \beta_i^{*2}}$$

We obtain the condition for action „a“ being optimal from:

$$\beta_i^* \cdot v_i(A)^* \le u_i(-c) + \beta_i^* \cdot v_i(B)^*$$

This gives the decision rule:

Choosing action “a” is optimal if: $0 \le u_i(-c) + \beta_i^* \cdot u_i(g)$.

Analogously the decision rule for choosing action “n” is obtained:

Choosing action “n” is optimal if: $0 > -u_i(c) + \beta_i^* \cdot u_i(g)$.

Note that these rules are similar to the decision rule for Game A, only the discounting rate of the game β is replaced by the individual discounting rate β_i^*. The interpretation of the criterion is as for Game A, if one replaces the discounting rate by the individual discounting rate: a player chooses the action which gives the highest expected utility for a one-period decision.

This decision criterion allows us to characterize player i by her cut-off value $\overline{\beta_i}$ for which player i is indifferent between action “a” and action ”n”. Only the utility function of a player determines $\overline{\beta_i}$ which characterizes the risk aversion of a player.

Types of Equilibria

We determine the different types of equilibria by means of the consistency condition ii). First the players are renamed such that after the renaming it holds for the cut-off value $\overline{\beta_i}$ of the players that

$$\overline{\beta_1} \geq \overline{\beta_2} \geq \overline{\beta_3} \geq ... \geq \overline{\beta_{N-1}} \geq \overline{\beta_N}$$

$$\text{Let } \beta^i = \begin{cases} (1-\frac{i-1}{N/2})\cdot\beta & \text{for i} \leq N/2 \\ 0 & \text{for i} > N/2 \end{cases}$$

$$\text{and } \bar{\text{i}} = \min\left\{ i \mid \beta^i \geq \overline{\beta_i} \text{ and } \beta^{i-1} < \overline{\beta_{i-1}} \right\}$$

For a determination of the types of equilibria we assume that the inequalities hold in the ordering, otherwise we only obtain degeneration: one player represents all players having the same cut-off values $\overline{\beta_i}$.

The types of equilibria can be characterized by the value of $\bar{\text{i}}$:

1) $\bar{\text{i}} = 1$: all players choose action “a” in the equilibrium

2) $\bar{\text{i}} = 2$: player 1 chooses action “n”, players 2, 3, ..,N choose action “a” in the equilibrium

3) $\bar{\text{i}} = 3$: player 1 and 2 choose “n”, players 3, 4, ..,N choose action “a” in the equilibrium

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N/2-1) $\bar{\text{i}} = N/2-1$: player 1, 2, .., N/2-1 choose action “n”, players N/2, ..,N choose action “a” in the equilibrium

N/2) $\bar{\text{i}} = N/2$: all players choose “n” in the equilibrium.

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N) $\bar{\text{i}} = N$: all players choose “n” in the equilibrium.

These types follow from explicitly exploring condition ii) and using the solution of the Bellman equations.

Up to type (N/2-1) these equilibria are monetary equilibria because money is accepted by at least two players who can make this decision and who switch groups. All other equilbria are non-monetary equilibria.

Special Cases:

In a symmetric equilibrium all cut-off values are identical: $\overline{\beta_{\mathrm{i}}} = \overline{\beta}$. If $\beta \geq \overline{\beta}$ (the discounting rate is smaller than or equal to the cut-off value) all players select action "a" which is a monetary equilibrium. If the discounting rate is bigger than the cut-off value, all players select action "n" which is a non-monetary equilibrium.

For risk neutrality $\overline{\beta_{\mathrm{i}}} = 0.5$.

Hypotheses

In an experimental analysis we test the three main results of the equilibrium predictions: if a player chooses action "a" once, she will choose it in every period (hypothesis 1), the break-off probability does not change from the individual decision making experiment to the game (hypothesis 2) and finally in equilibrium participants should react to the relative frequency of persons who select action "n" to obtain an estimate for their individual discounting rate (hypothesis 3).

The first hypothesis concerns the stationary behavior in Game A and Game B as it is obtained from solving the Bellman equations for theses games (compare section 3.2.1).

Hypothesis 1 (stationary strategies):

The participants choose action "a" for all periods if they choose it for one period. The choice of the action only depends on ß (For risk neutrality ß= 0.5 in Game A).

Hypothesis 2 compares the cut-off values in game A with the cut-off values in game B. The equilibrium prediction is that these values do not change if all players participate in game B. If not all players participate there will be an increase from game A to B.

Hypothesis 2 (Cut-off values):

The cut-off value $\overline{\beta_i}$ (that characterizes the risk aversion of a player) is the same in game A and game B.

In the third hypotheses we test the way players update the discounting. In the stationary equilibrium players do not use the discounting rate β for their decision, but a modified one in which the relative frequency of players playing "n" is included. Because it is not known how many players play "n" a player should take the relative frequency with which she experienced action "n" when she was in group B, as an estimate for this first frequency. Players should thus react on the relative frequency of "being disappointed" (of having made the experience that another player chooses action "n"). A player acting according to the equilibrium should update his personal discounting rate by including the relative frequency of being disappointed.

Hypothesis 3 (the discounting rate):

The decision of the participants to choose action "a" (or "n") depends on the relative frequency of "being disappointed".

Method

In the experiments 48 students from the University of Zurich were the participants. They were recruited by announcements in the university promising monetary reward contingent on performance in a group decision making experiment. The participants got points as payoffs. 1 point was 0.1 CHF (~$ 0.06). The average payoff of a participant was 40 SFr (~$ 25).

The experiment lasted approximately 90 minutes with the first 20 minutes consisting of orientation and instructions. The experiments were conducted in the computer laboratories of the University of Zurich. The experiment started with the instructions on the structure of the game and a learning phase in which the participants played single games. Game A was played without interaction between the participants at computer terminals. Game B was played in 6 groups of 8 participants via computer terminals[3]. The computer terminals were well separated from one another preventing communication between the participants. In the experiment the participants played the games for the following values of the parameters that all participants knew: the maximal number of periods was 70[4], β was 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 or 0.9. Players paid 10 points if they chose action "a" and provided a service and they received 20 points if they benefited from the service. The cost u_i(-c) was u_i(-10 points) and the benefit cost u_i(g) was cost u_i(20 points).

After the learning phase a strategy game was played. All participants selected their strategies for all games. The strategies could depend on the parameters of the game and also on the whole past of a play of the game, especially on ß, on the period and on the relative or the absolute number of being disappointed (a detailed description of the strategy game is given in the Appendix). One game was paid per type of game and per person. The participants were assigned to each other randomly in Game B. They were informed about this procedure.

After the experiment was completed each participant was separately paid in cash contingent on her performance.

Results

For a test of the predictions we analyze the strategy game. We use the results of the strategy game, because we are interested in the behavior of experienced players and want to minimize the effects of learning in the results. We also wanted to get behavior conditional on the actions of the other players to test our hypotheses concerning reciprocity. We obtain this conditional behavior from the strategies of the players.

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[3] In the learning phase small amounts of money were the payoffs. The participants received not more than 10% of their total payoff from these games.

[4] We selected 70 as the maximal number of periods, because it is known from experimental studies that participants do not perform backward induction for games with so many periods. In most cases they do not perform backward induction for more than 5 periods. It seems plausible that the participants act in a 70 period game as in the game with infinitely many periods if the last periods are not reached.

Game A

The strategies in Game A are of three types.

Type 1: Only depending on ß a participant using this strategy chooses action “a” for all periods or action “n” such that for $\beta < \overline{\beta_i}$ action “n” and for $\beta \geq \overline{\beta_i}$ action “a” is chosen. She has a cut-off value $\overline{\beta_i}$

Type 2: The participant using this strategy always chooses action “n”, if $\beta < \overline{\beta_i}$ .If $\beta \geq \overline{\beta_i}$ she chooses action “a” for only 15 periods.

Type 3: This participant always chooses action “n”, if $\beta < \overline{\beta_i}$, but with increasing ß the number of periods she chooses action “a” increases.

34 of the 48 strategies were of type 1, the rest were of type 2 and 3. In a $\chi^2 - \text{Test}$ the hypothesis that the types occur with the same probability is rejected on the 5%-level. This supports our hypothesis 1 that the optimization is stationary. In the sections parts we analyze these stationary strategies. Types 2 and 3 are compatible with the equilibrium prediction if one assumes a dependence of the decision on the payoffs accumulated in former periods as discussed for the solution of the Bellman equation in section 3.1.

Figure 3a shows the distribution of the cut-off values $\overline{\beta_i}$. We observe strong heterogeneity which is according to the solution of the Bellman equations attributed to the shape of the utility functions of the players. The median of $\overline{\beta_i}$ is 0.5. This is the prediction obtained under the assumption of risk neutrality. Taking 0.5 as a benchmark for risk neutral behavior 40 % of the subjects are risk averse, 40% are risk seeking and 20% are risk neutral as can be seen in Figure 3b.

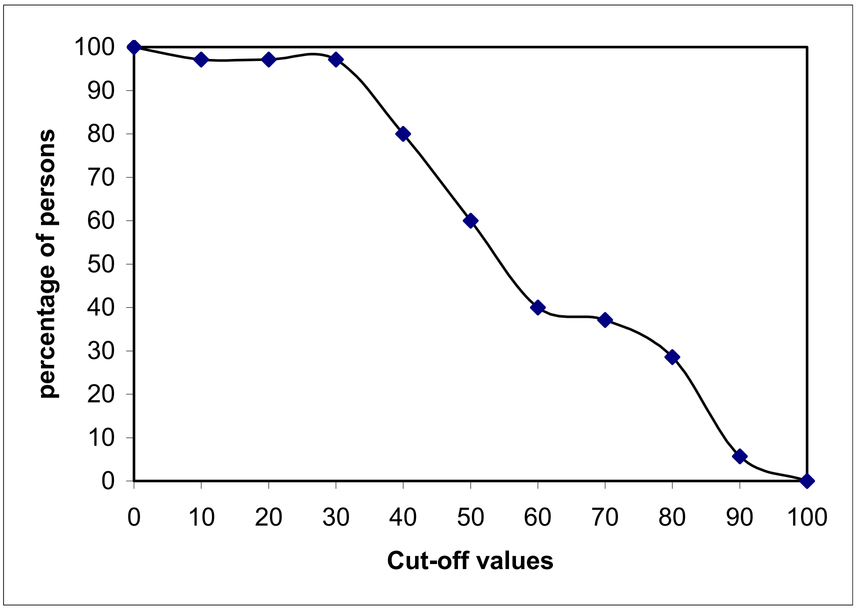
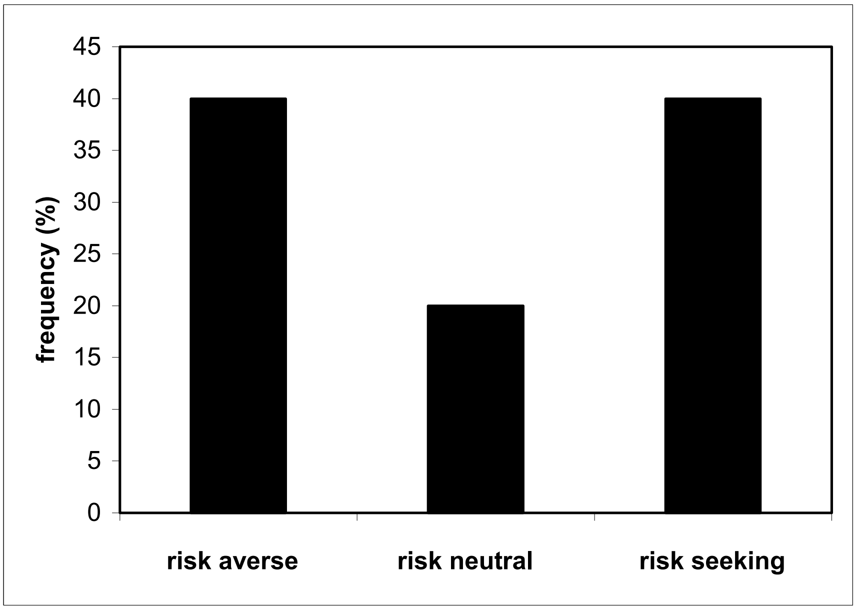


Figure 3: a: The cumulative distribution of the cut-off values $\overline{\beta}_i$ in Game A.



b: The frequencies of risk averse, risk neutral and risk seeking players.

Game B

We compare the results of Game B with the results of Game A to test the hypotheses 2. Concerning hypothesis 1 in Game B the same behavior is observed as in Game A. Because of the heterogeneity of the cut-off values $\overline{\beta_i}$ the asymmetric stationary equilibrium seems to be an adequate description of the result.

To test hypothesis 2 we look at the medians of the cut off-value $\overline{\beta_i}$ depending on the absolute number of being disappointed. We compare the results of Game A with the results of Game B for the case that a player has never been disappointed (which corresponds to game A). For this case only the discounting rate ß determines the decision of the player in Game B. The actions of the other players are such that they do not reduce ß. Figure 4 shows the distribution: if a player has never been disappointed the median of the cut-off-value is 0.3 (compared with 0.5 in Game A). Hence in the market game for all ß > 0.3 the median player continues to accept money while in the individual choice experiment only continuation probabilities of at least 0.5 the median player accepts money. For a test of hypothesis 2 we take the medians of the six independent groups. All medians show a decrease of the cut-off value. In a one-sided binomial test the hypothesis that $\overline{\beta_i}$ increases or is constant from Game A to B is rejected on the 2%-level. We therefore have the following experimental finding about the difference between individual optimization and a market.

Finding 1: The cut-off-values decrease from the individual optimization (game A) to the market (game B). Hence accepting money is a more likely outcome in the market.

Figure 4: The medians of the cut-off value $\overline{\beta}_i$ in Game B for different values of the absolute number of being disappointed.

For a test of hypothesis 3 we analyze whether the strategies of the participants depend on the absolute number of being disappointed or on the relative frequency. Table 2 shows the distribution: 28.6% of the strategies depend on the relative frequency and 71.4% depend on the absolute number. In a χ^2 – Test the hypothesis that it is equally likely that the strategy of a player depends on the relative frequency or on the absolute number is rejected on the 2% level. Assuming only independence of the 6 groups we compare whether the majority of the strategies in each group depends on the relative frequency or the absolute number. In 6 of 6 groups the majority of the strategies depend on the absolute number. In a one-sided binomial test the hypothesis that the probability that the majority of the strategies depend on the relative frequency is equal to or higher than the probability that the strategies depend on the absolute number is rejected on the 2% level.

Relative frequency of being disappointed determines the strategy	Absolute number of being disappointed determines the strategy
28,6%	71,4%

Table 2: Dependence of the strategies on the absolute number and the relative frequency of being disappointed

We therefore obtain the following experimental finding.

Finding 2: The choice of the action "n" depends on the absolute number of being disappointed in the market (game B) and not on the relative frequency. Every player who is disappointed 4 or more times will always choose action "n".

Possible reasons for different behavior in the market (game B) as compared to the individual optimization problem (game A).

To understand the experimental findings 1 and 2 we analyze the following considerations. Strategic reasoning, social conventions and positive reciprocity might explain our finding 1. We therefore look at the implications of these possible influence factors. For an explanation of our finding 2 we also look at the implications of negative reciprocity.

Finding 1: The cut-off value decreases from individual optimization to a market

Players might think that in a market they should choose action "a" for $\beta < \overline{\beta}$ (different from the individual optimization) to influence others to do the same which would then raise their own expected payoffs. However, this is not an equilibrium, because for any number of players following this rule their profit is lower than in the equilibrium given by the individual optimization. The payoff given by individual optimization is the maximal possible payoff in this game, because the probability of continuing cannot be greater than ß (exogenously given in the game) which is the same as in the individual optimization problem.

A social convention as for example playing cooperative in a prisoner's dilemma game which gives more to all players might change the behavior in the game. This convention might be a non equilibrium strategy combination with higher payoffs for all players. But again the payoff in the game cannot be higher than in the individual optimization problem, because in the game the probability of continuing cannot be greater than the exogenous discounting rate ß for which the payoff of a player is maximal.

A further explanation might be herding: participants accept money, because all others accept money. This explanation is problematic because of two reasons. The first reason is that participants do not observe the behavior of the others or at least of a majority of the others. They only know what result their strategic choice has had in every past period. Therefore they cannot follow the majority. Even if one did argue that they infer all others accept money from the fact that they have never been disappointed in the past and behaver according to this the experimental results are not in line with this explanation. On average the behavior in game A is the same as in game B if a participant has been disappointed once. Even if a participant knows that at least one other person does not accept money she still plays as in game A. Why should she do this knowing that she would not be the only one who does not accept money.

Since the reasons given so far seem to be inappropriate we now analyze positive reciprocity as reason for finding 1. For a better understanding we look at the trust game (Berg, Dickhaut and McCabe (1995)) and compare it with Game B (for the case of N=2, two persons with identical utility function u_i) when only two periods are played and ß=1: Player 1 can pay $u_i(-c)$, then player 2 receives $u_i(g)$ in period 1. In period 2 player 2 can pay $u_i(-c)$ and then player 1 will receive $u_i(g)$. Both can keep their money. If they do this, no additional payoffs occur. If both players pay $u_i(-c)$ their payoffs increase by $u_i(g)+u_i(-c)$ (if $u_i(g)>u_i(-c)$), but by a simple backward induction argument it is not rational to do this: player 2 should not pay the cost $u_i(-c)$ since it only decreases her payoff. This is a kind of trust game. The subgame perfect equilibrium of this game is that both keep their money.

If we look at this game played for infinitely many periods without discounting choosing action “a” and paying the cost $u_i(-c)$ every period is an equilibrium and optimal for both players. But how can reciprocity then be important in this game?

To discuss the effect of reciprocity we first have a look at existing theories of reciprocity (Fehr and Schmidt (1999) and references therein, Bolton and Ockenfels (2000) and references therein, Rabin (1993), Charness and Rabin (2000), Cox (2002)). In principal in the Fehr-Schmidt and Bolton-Ockenfels approaches persons obtain positive utility from inequity aversion. We say outcomes are “fairer ” if inequity is avoided. Other theories are based on different preferences or intentions. We do not want to engage in the detailed discussion distinguishing between these theories. We will only use that a person gets additional utility if outcomes are “fairer” afterwards, for example if inequity is avoided in the outcomes.

We look at the two person game played for infinitely many periods if $\beta<1$. In a symmetric equilibrium (all players have identical utility functions) both players get the same expected payoff. In this equilibrium no positive utility can be obtained from reciprocal behavior based on inequity aversion. In an asymmetric equilibrium the situation is different. We consider a game in which it is optimal for player 2 to choose action “n” and for player 1 to choose action “a” if both believe that β is the probability of ending the game. In equilibrium both will choose action “n”. But Player 2 will get positive utility $u_i(g)$, if player 1 starts and chooses action “a”. In equilibrium without considering reciprocity player 2 will not choose “a”. But if she chooses “a” she will get positive utility, because the outcomes are “fairer” afterwards. If this utility is high enough she will choose action “a” and the equilibrium with reciprocity is different from the one without, because player 2‘s cut-off value $\overline{\beta}_2$ decreases.

For a more rigorous treatment of the effect we introduce positive utility of "fairer" outcomes in the payoffs of the players. Fairer outcomes are determined by inequity aversion. Positive utility is only obtained if a player chooses action "a" (pays $u_i(-c)$), because the outcomes are "fairer" afterwards. The players get positive utility from positive reciprocity. How is this compatible with a stationary equilibrium? If "a" is chosen as action by one player in equilibrium at least N/2 other players choose also "a" in equilibrium, otherwise "n" is the choice of all players in equilibrium (see 3.2.2 types of equilibria). These players obtain positive utility from choosing action "a" because the outcomes of these players in an asymmetric equilibrium are fairer afterwards. If action "n" is the optimal response for all players no additional utility is obtained by this action. We formalize this by replacing the payoff $u_i(-c)$ by $u_i(-c,r)$, where r is a parameter describing the fairness of outcomes as discussed above. The ways to formalize the theory of reciprocity work in the same direction. If "a" is chosen in a stationary equilibrium, the payoff $u_i(-c,r) > u_i(-c)$ because of positive reciprocity, if "n" is chosen $u_i(-c,r)=u_i(-c)$. Formally in the Bellman equations in the definition of the stationary equilibrium $u_i(-c)$ is replaced by $u_i(-c,r)$. This changes the decision criterion in the equilibrium. It is:

Choosing action "a" is optimal if: $0 \le u_i(-c,r) + \beta_i^* \cdot u_i(g)$.

Choosing action "n" is optimal if: $0 > u_i(-c,r) + \beta_i^* \cdot u_i(g)$.

If $u_i(-c,r) > u_i(-c)$, because of reciprocity as described above the cut-off value $\overline{\beta}_i$ decreases. As discussed above this can only take place in an asymmetric equilibrium, because in a symmetric equilibrium all payoffs are the same.

Anonymity is a point of discussion that is left. If N>2, players do not play every period with the same player for sure. A player only knows that her opponent is out of a group of seven. This case is comparable with a strangers design in public good games in which the opponents with whom the game is played change every period. For public good games the difference between partners (always playing with the same player) and the strangers design have been analyzed experimentally (Keser and van Winden (2000)). In the strangers design reciprocal behavior is less frequently observed as in the partners design, but it is present and has a strong impact.

We therefore conclude that positive reciprocity is an explanation of our finding 1. Positive reciprocity seems to make an asymmetric equilibrium “fairer”. Less inequity is achieved by reciprocity. As an effect those players who benefited from other players choosing “a” tend to chose “a” for smaller continuation probabilities because by doing this the overall distribution of payoffs becomes more equal. . Another possible equilibrium is that all players choose “n”, but this equilibrium is not achieved by considerations about positive reciprocity, since choosing action “n” instead of action “a” only reduces the total payoff of a player, if action “a” gives her positive payoff without considering reciprocity. We discuss the influence of negative reciprocity in the next section

Finding 2: The choices of players depend on the absolute number of being disappointed

The discussion of the cases in which negative reciprocity can occur is similar to the one for positive reciprocity. Negative reciprocity can only occur in an asymmetric equilibrium. But the consequences of negative reciprocity are different from the ones of positive reciprocity. We consider the case that in a period a player for whom it is optimal in an equilibrium to choose action “a” does not get the payoff $u_i(g)$, because it is not optimal for the player she is matched with to pay $u_i(-c)$. How will the first player react if this happened two or three times? It is known from experimental studies (Fehr, Schmidt 1999 and references therein, Bolton, Ockenfels 2000 and references therein) that she will punish the others. The only way to punish the others is to choose action “n” which reduces the payoffs of the other players. This form of punishment depends on the absolute number with which the player has been disappointed in the former periods and not on the relative frequency as an attempt to estimate the probability of the value β_i in equilibrium would suggest. The maximal absolute number which is necessary for the punishment is 4 in the experiment. We conclude that negative reciprocity is an explanation of our finding 2.

An counter argument to our finding and explanation might be that the reaction will not depend on the absolute number of being diasppointed if being disappointed for 4 times happens within 1000000 periods. This might be true, but persons have a limited short term memory. Therefore they will not remember the 4 times. A restriction to our finding might be that the number of being disappointed has to occur within the capacity of the short term memory which includes the influence of proportional updating, but it is by no means as proposed by rational behavior. Therefore the interpretation of this behavior as negative reciprocity should be still valid and the consequence discussed in the next paragraph should also hold.

A consequence of this form of punishment is that it will cause a breakdown of choosing action “a”, if only one player chooses action “n”. If all players play strategies of the type of finding 2 and only one player chooses “n”, in a stationary equilibrium all players choose “n”. This leads to a non monetary equilibrium. The breakdown is caused by the fact that after some periods a second player has been disappointed for enough times and will also choose action “a”. After some periods a third player will punish and choose action “n”. This will continue until all players choose action “n”. This argument only depends on the fact that the punishment depends on the absolute number of being disappointed.

Conclusions

The main theoretical results of this paper are that for the market considered a stationary equilibrium can be defined and characterized. In particular agents’ strategies are allowed to be heterogenous. Monetary and non monetary equilibria exist depending on the discounting rate and the utility functions of the players. The main characteristics of monetary equilibria are that the strategies depend only on a cut-off probability of a player. Every period she chooses the same strategy in a game with fixed discounting rate. With decreasing discounting rate the choice of accepting money becomes more favorable. Positive reciprocity causes a decrease in the cut-off probabilities of the players in an asymmetric equilibrium as compared to the individual optimization game. In a symmetric equilibrium reciprocity has no influence on the results. An Interpretation of this result is that reciprocity seems to make an asymmetric equilibrium “fairer or more symmetric”.

Punishment due to negative reciprocity causes a dependence of the strategies on the absolute number of being disappointed and not on the relative frequency as expected for the updating of the individual discounting rate. This dependence causes the break down of a monetary system if only one player does not accept money because with probability one every other player will be matched to this player infinitely often.

Hence due to positive reciprocity a monetary system is more stable than individual rationality would suggest, provided every participant considers accepting money as a reasonable option. If however some participants notoriously refuse to accept money then due to negative reciprocity their behavior will eventually induce a break down of the monetary system.

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