CFS Working Paper Series

No. 496

Maria Bigoni, Gabriele Camera, Marco Casari

Money is more than memory

The CFS Working Paper Series

presents ongoing research on selected topics in the fields of money, banking and finance. The papers are circulated to encourage discussion and comment. Any opinions expressed in CFS Working Papers are those of the author(s) and not of the CFS.

The Center for Financial Studies, located in Goethe University Frankfurt's House of Finance, conducts independent and internationally oriented research in important areas of Finance. It serves as a forum for dialogue between academia, policy-making institutions and the financial industry. It offers a platform for top-level fundamental research as well as applied research relevant for the financial sector in Europe. CFS is funded by the non-profit-organization Gesellschaft für Kapitalmarktforschung e.V. (GfK). Established in 1967 and closely affiliated with the University of Frankfurt, it provides a strong link between the financial community and academia. GfK members comprise major players in Germany's financial industry. The funding institutions do not give prior review to CFS publications, nor do they necessarily share the views expressed therein.

Money is more than memory*

Maria Bigoni
University of Bologna

Gabriele Camera
ESI–Chapman University
& University of Basel

Marco Casari
University of Bologna
& IZA

October 27, 2014

Abstract

Impersonal exchange is the hallmark of an advanced society. One key institution for impersonal exchange is money, which economic theory considers just a primitive arrangement for monitoring past conduct in society. If so, then a public record of past actions—or *memory*—supersedes the function performed by money. This intriguing theoretical postulate remains untested. In an experiment, we show that the suggested functional equality between money and memory does not translate into an empirical equivalence. Monetary systems perform a richer set of functions than just revealing past behaviors, which proves to be crucial in promoting large-scale cooperation.

Keywords: Cooperation, intertemporal trade, experiments, social norms, social dilemmas.
JEL codes: C70, C90, D03, E02

* We thank Vincent Bourke for outstanding research support, Bart Wilson and seminar participants at several universities, including Bologna, Chapman, Goethe, Heidelberg, Missouri, UCSD, the Central Bank of Sweden, the European University Institute, the Stockholm Institute of Transition Economics for comments. G. Camera acknowledges partial research support through the NSF grant CCF-1101627. M. Casari acknowledges financial support through the ERC Starting Grant number 241196. Correspondence address: Gabriele Camera, Economic Science Institute, Chapman University, One University Dr., Orange, CA 92866; e-mail: camera@chapman.edu.

1 Introduction

Humans have a demonstrated inclination for cooperation (Bowles and Gintis, 2011) but such predisposition is weakened when the sphere of interaction expands from personal to *impersonal* (North, 1991). In advanced societies many interactions take place among strangers. Strangers cannot rely on the motivational forces of reciprocity and reputation to discourage opportunism (Binmore, 2011; McCabe et al., 1998; Ostrom, 2010), which is why self-enforcing norms of mutual support tend to falter when reciprocal relationships cannot be formed and individual conduct is kept private—even if play is repeated and full cooperation is within theoretical reach (Camera and Casari, 2009; Camera et al., 2013).

The challenges of sustaining cooperation through impersonal interaction and exchange have led to the creation of institutions such as property rights, rules of governance, and accounting systems (Basu et al., 2009; Greif, 2006; Kimbrough et al., 2008). Our focus is on an institution that is ubiquitous across regions, cultures and historical periods, but whose nature continues to be enigmatic: money. Modern economics has provided strong theoretical foundations for Adam Smith's observation (Smith, 1776, Chapter 4) that the existence of money stems from the efficiency gains generated by exchanging symbolic objects compared to barter or gift-exchange (Kiyotaki and Wright, 1989; Kranton, 1996). Yet, the *mechanism* behind this result remains open to debate and little is known about whether superior alternatives to money exist in this digital era. This study reports the results of a unique experiment designed to fill these important gaps.

Economic theory espouses the notion that money is essentially a crude system for monitoring counterparts' behaviors—a type of public "memory"—

because it is *exclusively* used to share information about past conduct (Kocherlakota, 1998; Ostroy, 1973; Townsend, 1987). Moreover, the theory considers money subordinate to systems for public monitoring of actions because it tacitly assumes that individuals would *choose* to use such monitoring systems to replicate or to improve upon monetary trade.[1] This theory remains untested. Experimental exploration is meaningful not only because the theory allows for multiple equilibria, and simply presumes selection of the efficient one, but also because understanding the inner workings of monetary systems can generate valuable insights into the function and (in)stability of traditional monetary systems (see New York Times, 2011) and of the usefulness of the alternatives presented by digital networks such as Bitcoin (see Krugman, 2013).

The experiment consists of a cooperative task that involves eight subjects and is repeated for an indefinite number of periods. In each period, subjects meet in pairs, where one has the option to help the other at a cost. Everyone has repeated opportunities to help and to receive help because roles alternate over time. Pairs are formed at random in every period and identities remain hidden, so the subjects interact as *strangers*. Cooperation requires trusting that help given to a stranger will be returned by a stranger later in the game.

There are three treatments: BASELINE, which serves as a control, MONEY and MEMORY. To facilitate cooperation, in all treatments subjects can see when everyone in the group helps. This type of public monitoring is theoretically sufficient to support any cooperation level, from zero to one-hundred percent (folk theorem). Here lies a social dilemma with two intertwined issues: *opportunism*, due to the short-run temptation to avoid helping others, and *co-*

[1] For instance, Corbae et al. (2003, p.737) write: "It is well known that there is no role for money [...] precisely because there is perfect memory [...]. The argument is the following: anything we could do with tangible money, we can do without it simply by keeping track in our memory of how the money would have changed hands in a monetary equilibrium."

ordination, due to the existence of multiple equilibria, including the efficient outcome corresponding to full cooperation. In Money we add a fixed amount of intrinsically worthless electronic *tokens*, which participants can *choose* to exchange for help or hold as balances. Memory adds a *record-keeping* system based on numeric balances—positive or negative—that rise for those who help and fall for those who receive help. In this design tokens and record-keeping are theoretically irrelevant in the sense that in all treatments there already exists a self-enforcing norm capable to support the efficient outcome. However, in Money and Memory subjects can also support the efficient outcome by conditioning help on observed balances. In this sense, tokens and record-keeping are theoretically affine: balances in Memory can be employed to replicate a pattern of monetary trade without transferring tokens, while tokens can communicate a subject's past conduct without the need to rely on any additional public monitoring. Through this design we can uncover behavioral differences between monetary systems and systems for maintaining and sharing information about past conduct.

We report three main findings. First, public monitoring was not sufficient to sustain long-run cooperation, when in fact theory suggests it could. Our control groups fell short of achieving efficient outcomes. Second, tokens and record-keeping each significantly boosted long-run cooperation, when in fact theory suggests they would not play a role. In Money subjects traded help for intrinsically worthless tokens, which endogenously became money. In Memory help was also conditioned on the opponent's balance, but not in a manner that superseded the function performed by tokens. In fact, record-keeping was not employed to replicate monetary trade but, instead, to sustain a less efficient pattern. Our third and most crucial finding is that long-run cooperation was significantly higher in Money than in Memory. Money encouraged cooperation because subjects took turns at trading tokens for help, without accumulating them. Such alternation did not emerge in Memory where there was instead a tendency to accumulate large balances, either negative or positive.

The experiment provides unique evidence that the introduction of systems for maintaining and sharing information about past conduct failed to provide dynamic incentives to cooperate that match those of the monetary system that *endogenously* emerged when tokens were made available. This suggests that monetary exchange is behaviorally more effective at promoting cooperation than alternative record-keeping systems. We have identified some key characteristics of this superior performance: money simplifies the task of coordinating on credible, incentive-compatible schemes to punish strangers who free ride. Consequently, monetary trade redistributes surplus from free-riders to cooperators much more effectively than the record-keeping system.

The paper proceeds as follows. Section 2 describes the design. Section 3 presents the theory behind the experiment. Section 4 reports the main results. Section 5 puts the paper in the context of the experimental literature, and Section 6 contains a discussion and draws some conclusions.

2 Experimental design

The experiment has three treatments: Baseline, Money and Memory (Table 1). In all treatments subjects face a cooperative task that is repeated an indefinite number of periods, where every period subjects encounter a random counterpart and play in pairs. Interactions are anonymous, and any form of communication is ruled out. The design in Baseline is described next.

Variable	Treatment		
	BASELINE	MONEY	MEMORY
Group size	8	8	8
Tokens	No	Yes	No
Record-keeping	No	No	Yes
Sessions	4	4	5
Subjects	96	96	120
Supergames	20	20	25
Periods played (avg.)	111.5	116.2	117.6

Table 1: Sessions and treatments

Notes: The last four rows report the number of observations. Sessions' dates (dd-mm-yy): BASELINE, 6-2-12 (two), 24-1-14, 20-2-12; MONEY, 7-2-12 (two), 24-1-14, 16-2-12; MEMORY, 13-2-12 (two), 21- & 23-1-14, 27-1-14. The 2012 sessions were conducted at Purdue University, in the VSEEL lab. The 2014 sessions were conducted at Chapman University, in the ESI lab. The sessions on 20-2-12, 16-2-12, and 27-1-14 were run with experienced subjects (=experienced sessions): participants were informed that everyone in their session had previously participated in an experiment with the same treatment.

2.1 Interaction in a period

Each period subjects meet in pairs and play a "helping game" (Table 2). In this game, one subject is a producer, and the other is a consumer. The producer has a good, which he can consume or transfer to the consumer, who values it more. In this case, we say that the producer "helps" the consumer. The consumer has no action to take. Hence, it is an individual decision problem.

	Producer	
	Y	Z
Consumer	$d-l, d$	$g, 0$

Table 2: Payoffs in the stage "game" in BASELINE and MEMORY

Notes: In the experiment d=6, l=2, g=20.

In BASELINE the consumer has no action to take (Table 2). The producer chooses either outcome Z (=*Help*) or Y (= *Do not help*). Payoffs to consumer and producer are, respectively, g and 0 if the producer helps; otherwise, they are $d-l$ and d, with $g > 2d-l > 0$. In the experiment $d = 6$, $l = 2$, $g = 20$ and each point is worth \$0.03. Surplus in a pair is maximum when the producer helps, which generates $g - (2d - l) = 10$ points. We refer to this outcome as the (socially) efficient outcome or, alternatively, *cooperation*. The dominant strategy is not to help, which we call *defection*. At the end of the interaction actions and outcome in the pair are observed by both agents.

2.2 The supergame

A session is divided into five separate supergames. In a supergame, subjects interact within a fixed group of eight subjects, for an indefinite number of periods. A group is comprised of four producers and four consumers with deterministically alternating roles. At the start of every period each consumer meets a producer at random. According to this matching protocol, there is only a 0.25 probability to be in the same pair in two consecutive periods.[2] Participants can never identify their opponent. Hence, subjects interact as strangers because opponents change at random and are anonymous.

The duration of the supergame is determined by a random continuation rule (Roth and Murnighan, 1978). A supergame has 20 fixed periods after which the game continues into an additional period with probability 0.75, which we interpret as the discount factor of a risk-neutral subject. The design guarantees an interaction of finite but uncertain duration. The expected duration of a supergame is 23 periods; from period 20, in each period the

[2]There are 4! ways to match four producers to four consumers; in 3! of such pairings consumer j meets producer i. In each period one pairing is chosen with equal probability.

supergame is expected to go on for 3 additional periods. In the experiment a computer randomly selects an integer number between 1 and 100, using a uniform distribution, and the supergame ends when a number greater that 75 is selected. At the end of each period all participants in the group observe the number drawn, which informs them about the end or continuation of the supergame, and can also serve as a public coordination device. Subjects also observe whether or not outcomes were identical in all four pairs. This second statistic provides a form of anonymous public monitoring, which is introduced to ensure that the minimum discount factor that supports full cooperation in sequential equilibrium remains constant across treatments (see Section 4).[3]

Every experimental session involves twenty-four subjects, who were divided into three groups in each supergame for a total of fifteen groups per session. Supergames terminate simultaneously for all groups. Each group is constructed so that no two subjects can interact in more than one supergame.[4]

2.3 Money and Memory treatments

The Money treatment adds indivisible, intrinsically worthless electronic objects called "tokens," which neither yield nor can be redeemed for points or dollars. In period 1 of each supergame, every consumer is endowed with one token, hence there are four tokens per group; this supply is known and remains fixed throughout the supergame. Tokens can be transferred from consumer to producer, one at a time, and can be carried over to the next period but not to

[3] The design uses a form of public monitoring that may also simplify coordination tasks compared to other forms of public monitoring, such as making public the frequency of actions in the group. A red flag is a signal less open to interpretation than a frequency-based signal.

[4] Adding supergames would have introduced the possibility of contagion across groups; some participants would have interacted in multiple supergames. Subjects are informed of this matching protocol across supergames, which is applied in a predetermined fashion.

the next supergame. Participants can hold any positive balance of tokens.[5]

The introduction of tokens expands the actions sets relative to Baseline because the stage game now includes unconditional and *conditional* actions (Table 3). A consumer can either keep the tokens (=*give* 0), transfer one to the producer (=*give* 1), transfer one conditionally on receiving help (=1 *for* Z) or on receiving *no* help (=1 *for* Y). The producer can choose to unconditionally help (= Z) or not (= Y), but can also choose to help *conditionally* on receiving either one token (=Z *for* 1) or *none* (=Z *for* 0). Subjects choose simultaneously and without prior communication, hence, they cannot signal a desire to cooperate by requesting or offering a token. In particular, nothing ever prevents producers from giving help, if they wish to do so. Outcomes and payoffs associated with each pair of choices are in Table 3.

Several remarks are in order. First, the availability of conditional actions might facilitate coordination on cooperation. The producer can choose to help conditional upon receiving a token, and the consumer can choose to transfer one token conditional upon being helped. Helping only in return for a token is a form of monetary exchange, which can also be achieved by choosing the unconditional actions Z and *give* 1.

Second, to avoid biasing the results in favor of the emergence of monetary exchange the design includes conditional actions that are antithetical to monetary exchange. By choosing Z *for* 0, the producer commits to execute Z only if the consumer chooses *give* 0. By choosing 1 *for* Y, the consumer commits to transfer a token if the producer *avoids* Z. Hence, tokens may take on a

[5] In contrast with Camera et al. (2013) and Camera and Casari (2014) here subjects deterministically alternate between the roles of consumer and producer (rather than randomly), and their token holdings are unrestricted (instead of being bounded). This simplifies the experimental tasks relative to the earlier design, it facilitates coordination on cooperation and it makes monetary exchange consistent with full efficiency.

		Producer			
		Y	Z	Z *for* 1	Z *for* 0
	give 0	$d-l, d$	$g, 0$	$d-l, d$	$g, 0$
Consumer	*give* 1	$d-l, d^*$	$g, 0^*$	$g, 0^*$	$d-l, d^*$
	1 *for* Z	$d-l, d$	$g, 0^*$	$g, 0^*$	$d-l, d$
	1 *for* Y	$d-l, d^*$	$g, 0$	$d-l, d^*$	$d-l, d^*$

Table 3: The augmented stage game in Money

Notes: The superscript * indicates outcomes where the producer receives a token from the consumer. In the experiment d=6, l=2, g=20.

negative connotation as subjects could use them to tag defectors by giving tokens to those who do not help. Given this richer action set, the addition of tokens might increase coordination problems, relative to Baseline.

Third, subjects cannot create or borrow tokens. Hence, a consumer without tokens has no action to take, as in Baseline. Such possibility of being "liquidity constrained" is at the heart of monetary economics. It is also central to our study because it allows us to investigate whether removing such constraints through record-keeping helps to improve overall efficiency. Subjects are informed whether a token transfer is feasible in their pair; the design minimizes the chance that such information might indirectly identify the opponent. Before making their choice, subjects can see whether the opponent's balance of tokens is positive or zero, but not the exact number of tokens held. The restriction to transfer one token at a time is not theoretically binding in monetary equilibrium.

Finally, though subjects can hold any number of tokens, a balance of one token per consumer is all that is needed for the monetary system to function efficiently because with deterministic alternation of roles there is no precautionary motive to hold tokens (see Section 4). This explains our choice for the tokens' supply: with less than four tokens monetary exchange would be sometimes unfeasible; adding tokens cannot increase the cooperation frequency, and in fact would undermine it by reducing the endogenous value of tokens.

The MEMORY treatment retains the BASELINE stage game and adds an information-sharing system called (*public*) *record-keeping*. The system assigns to each subject a numeric *balance* ("personal index," in the experiment), which tallies the help given and received in the past. The initial balance is 1 for consumers, 0 for producers. As in MONEY, balances are intrinsically worthless and subjects only see if the opponent's balance is positive or not. The difference with MONEY is that balances are automatically updated at the end of each interaction, based only on the producer's action. If Y is chosen, then balances in the pair do not change. If Z is chosen, then the producer's balance increases by one and the consumer's falls by one; balances can be negative. If subjects condition their help on balances in their pair, then MEMORY simplifies coordination tasks relative to MONEY because choice sets are smaller (as in BASELINE) and balance updates are automatic.

Considering all treatments, we recruited 312 subjects through announcements in undergraduate classes, at Purdue University and at Chapman University. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Instructions (a copy is in Appendix C) were read aloud at the start of the experiment and left on the subjects' desks. No eye contact was possible among subjects. Average earnings were \$28.75 per subject ($\min = \$18.85, \max = \$40.95$). On average, a session lasted 115 periods for a running time of about 85 minutes (min = 72 minutes, max = 108 minutes) excluding instruction reading, a quiz, and payments (Table 1).

3 Theoretical considerations

Here we show that full cooperation is an equilibrium outcome in all treatments. It can be supported either by adopting a social norm of cooperation or, alternatively, by using tokens or record-keeping. The Appendix A reports proofs and mathematical details. Consider the following strategy:

Definition 1 (Cooperative strategy). *As a producer, the agent* cooperates *(selects Z) as long as she has not observed a* defection *(Y). If a defection is observed, then the agent defects forever after.*

If everyone adopts this strategy, then we call it a *social norm*. This norm consists of a rule of cooperation and a rule of punishment that sanctions any uncooperative action with permanent defection by the entire group. If agents are sufficiently patient, then the punishment threat can adequately deter *any* defection from ever occurring and full cooperation is a sequential equilibrium.

Proposition 1. *If* $\beta \geq \beta^* := \dfrac{d}{g-d+l}$, *then the strategy in Definition 1 supports full cooperation in sequential equilibrium.*

The threshold value β^* is the cost-benefit ratio of cooperating: the producer's cost from helping is divided by the consumer's surplus from being helped. The condition $\beta \geq \beta^*$ is sufficient and necessary for existence of cooperative equilibrium but does not guarantee that it will be realized instead of another outcome with lower efficiency. In fact, thanks to public monitoring of defections, a continuum of equilibria exists ranging from full defection to full cooperation. Full defection is always an equilibrium because it consists of an infinite repetition of the static Nash equilibrium strategy (Y). Full cooperation is socially efficient because it maximizes surplus in all meetings.

To prove that full cooperation is an equilibrium two conditions must be checked. First, in equilibrium, no producer should prefer to defect. Second, out of equilibrium no producer should prefer to cooperate. The latter condition is immediately verified: any equilibrium defection is publicly observed, hence, everyone defects forever after and there is no longer a reason to cooperate. The first condition requires checking that a producer cannot improve her payoff by moving off equilibrium (unimprovability criterion). Discounting starts on period $T = 20$, which is when the incentives to cooperate are the smallest. Hence, it is sufficient to consider continuation payoffs at the start of any period $t \geq T$. Denote v_s the equilibrium payoff to an agent in state $s = 0, 1$ ($0 =$ producer, $1 =$ consumer). It holds that $v_1 > v_0$ with

$$v_s := \frac{\beta^{1-s}}{1-\beta^2} \times g \qquad \text{for } s = 0, 1,$$

given the alternation between production (earn 0) and consumption (earn g).

To show that producers do not want to move off equilibrium, suppose a producer defects in period $t \geq T$. Her payoff satisfies

$$\hat{v}_0 := \frac{d + \beta(d-l)}{1-\beta^2}$$

because she earns d today (instead of 0) but causes cooperation to forever stop from $t+1$ on. It follows that $v_0 \geq \hat{v}_0$ for all $\beta \geq \beta^*$. The design parameters yield $\beta^* = 0.375$, so under reasonable assumptions about subjects' risk attitudes cooperation is an equilibrium in every treatment because in the experiment the continuation probability from period 20 on is 0.75.

3.1 Equilibrium with tokens

Adding tokens expands action and strategy sets, hence the set of outcomes. In Money subjects can exchange tokens and see whether the opponent's balance of tokens is positive or not. This does not eliminate *any* of the equilibria possible in Baseline because agents can always adopt strategies that ignore tokens, since tokens have no intrinsic value. Yet, there are ways in tokens can be used to support full cooperation. Following the insights from monetary theory, we focus on a strategy that conditions actions on the observable *balances* in the pair, identified by the letters H (=positive) and L (=zero).

Definition 2 (**Monetary trade strategy**). *In any period and after any history: as a consumer, the agent transfers one token conditional on receiving help only if her balance is H—otherwise she has no action to take. As a producer, the agent helps conditional on receiving a token only if her balance is L—otherwise she does not help.*

If everyone adopts the strategy in Definition 2, then tokens are exchanged quid-pro-quo for help, hence become a medium of exchange. The resulting outcome is called *monetary trade*. In equilibrium all encounters are *trade meetings* in which the consumer "buys" help by transferring the only token she has to a producer without tokens. The monetary trade strategy is cognitively simple: it is history-independent and does not require any switch in behavior as a reaction to an observed defection. Off-equilibrium a producer may have tokens or a consumer may have none, in which case tokens are not exchanged and help is not given.

Monetary trade does not expand theoretical efficiency. The equilibrium consumption pattern mirrors that seen under the social norm—so payoffs coincide with v_0 for a producer and v_1 for a consumer—and is supported on the same parameter set of the social norm.

Proposition 2. *If $\beta \geq \beta^*$, then monetary trade supports full cooperation as an equilibrium.*

In monetary equilibrium a producer who refuses to help is "punished" by not receiving a token. The agent will not be able to consume next period, much as it happens under the social norm, albeit for different reasons. This explains why the lower bound β^* is the same as under the social norm.

To prove Proposition 2 consider payoffs at the start of any period $t \geq T$, without loss of generality. We need to show that in a trade meeting the consumer prefers to spend her token to receive help, and the producer prefers to help to receive a token. The first part of the statement is always true because the consumer earns some surplus from trading. The latter part of the statement is true only if the producer—who sustains a cost d to help—can spend the token fairly soon or, equivalently, is sufficiently patient.

To formalize this intuition consider one-time unilateral deviations. Off-equilibrium payoffs are calculated adopting recursive arguments, exploiting the fact that the monetary trade strategy is history-invariant; hence, equilibrium deviations temporarily alter the tokens' distribution but never trigger a switch in behavior. Monetary trade thus allows agents to easily re-coordinate on equilibrium play two periods after a unilateral deviation occurs.

Consumer i has an incentive to trade a token for help if

$$d - l + \beta(d + \beta v_1) < v_1 = g + \beta(0 + \beta v_1),$$

which always holds because $g > d + d - l$. To interpret the inequality note that defecting in t gives payoff $d - l$ (instead of g) to consumer i; she enters period $t + 1$ as a producer *with* money and reverts back to following monetary trade. Hence, the defection changes the distribution of tokens only temporarily: two periods after consumer i deviates the tokens' distribution is back at equilibrium. In $t+1$ player i is a producer who refuses to help because it would costs her d and she has already one token to spend in $t+2$. In $t+2$ the distribution of tokens is back at equilibrium since all consumers have money (player i is one of them) and producers have none.

Producer i has an incentive to help in exchange for a token if

$$d + \beta(d - l + \beta v_0) < v_0 = 0 + \beta(g + \beta v_0),$$

which holds whenever $\beta \geq \beta^*$. Defecting in t generates payoff d instead of 0, and in $t+1$ the agent becomes a consumer *without* money. Being unable to buy help she earns $d-l$ and enters $t+2$ as a producer without money. Hence, in $t+2$ the tokens' distribution is back at equilibrium.

3.2 Equilibrium with record-keeping

Adding record-keeping leaves unaltered the action sets compared to Baseline. It enriches the strategy sets because producers can now condition actions on observed balances, denoted L (0 or below) and H (1 or above). This eliminates none of the equilibria that are possible in Baseline because agents can always adopt strategies that ignore balances. Yet, there are ways in which balances can be employed to support full cooperation. In particular, subjects can replicate the monetary trade strategy without the need to exchange symbolic objects. Hence, outcomes exist in which balances convey the same information about past actions as under monetary exchange.[6]

[6]Not all outcomes convey the same information, of course. The statistics L and H provide information about past actions that *might* differ in the two treatments because in Memory producers can always increase their balance by helping *any* consumer. For instance, in Memory a consumer with balance L surely did not help in the past, but this might not be so in Money—she might have helped without receiving a token. Considering all possible ways to sustain cooperation with record-keeping is not our objective. Our goal is to understand whether tokens are employed purely as a tool to communicate past conduct—as theory suggests—or if they play a richer function.

Definition 3 (**Trade strategy**)**.** *In any period and after any history, the agent can take an action only as a producer. If her balance is L, then she helps only consumers with balance H. In all other circumstances she does not help.*

This strategy supports full cooperation because, as in Definition 2, help is *conditioned* on balances in the pair. Producers help only to increase their balance above zero, and do so only if the consumer's balance is H. It immediately follows that the trade strategy also supports full cooperation when $\beta \geq \beta^*$.

There are two important behavioral differences between using balances to support monetary trade in Money and trade in Memory. First, the record-keeping system simplifies coordination on efficient trading because only producers make choices and balances are automatically updated whenever help is given. In contrast, the monetary system requires producer and consumer to coordinate on the exchange of tokens in every meeting. Second, producers should not help consumers with balance L, but the incentives to do so differ across treatments. They are strong under monetary trade because producers cannot increase their balance by helping consumers without tokens. This is not so in Memory since helping always increases the producer's balance. Hence, producers with balance L may be tempted to help someone they should in fact punish.

4 Results

We report six main results that address the following questions: if defections are public, is full cooperation easy to sustain? When monetary trade is possible, do subjects attain different cooperation rates than when it is not? Does a system designed to maintain and share information about past conduct supersede the function performed by money?

All analyses consider only the first twenty periods in each supergame and take as unit of observation, unless otherwise noted, the average choice of each subject in a supergame. All results rely on sessions run with inexperienced subjects, except Result 6 that explicitly addresses the issue of experience.

Result 1. *Cooperation was difficult to support in the* BASELINE *treatment.*

Support for Result 1 is provided by Figure 1 and Table 4. The average cooperation level in the BASELINE treatment ranges from 59% in the first supergame to 47% in the last supergame.[7] Aggregate efficiency is proportional to the frequency of cooperation in the group. The levels achieved in BASELINE are well below full efficiency and present a declining trend as the subjects gain experience across supergames (Figure 1). This declining trend is statistically significant at the 5% level as illustrated by the panel regression in Table 4, model 1. The dependent variable is the average cooperation frequency of a subject in a supergame and the regression controls for individual characteristics. The message is that subjects did not trust that strangers would return a gift of help in the future. There is scope for institutions to promote cooperation.

Result 2. *In the long-run, cooperation and efficiency were greater in* MONEY *and* MEMORY *compared to* BASELINE.

Support for Result 2 is provided by Figure 1 and Tables 4-5. In the last supergame, average cooperation is 72% in MONEY and 60% in MEMORY. The differences in cooperation with BASELINE are statistically significant according to a linear regression (1% and 5% level, respectively; Table 5). Contrary to the BASELINE treatment, in MONEY there is a significant positive trend with experience (Table 4, model 2). The MEMORY treatment exhibits a weaker positive trend (significant at a 10% level).

[7] The minimum and maximum cooperation rates observed in a supergame are as follows 10% and 85% in BASELINE; 23% and 95% in MONEY; 19% and 100% in MEMORY. Inexperienced subjects only.

Dependent variable: *Individual frequency of cooperation*	Model 1 (Baseline) Estimate	S.E.	Model 2 (All treatments) Estimate	S.E.
Supergame	-0.031**	0.016	-0.031**	0.013
Money			-0.266***	0.069
Money x Supergame			0.106***	0.018
Memory			-0.102	0.063
Memory x Supergame			0.045***	0.016
Constant	0.308**	0.127	0.438***	0.103
Controls	Yes		Yes	
N. of obs. (N. of subjects)	360 (72)		1200 (240)	
R-squared within	0.064		0.126	
R-squared between	0.259		0.212	
R-squared overall	0.179		0.172	

Table 4: Cooperation frequency.

Notes: One observation per subject per supergame. Inexperienced sessions, all supergames. Panel regression with random effects at the individual level and standard errors (S.E.) robust for clustering at the session level. The estimated coefficients for *Money* and *Memory* are significantly different at the 1% level (p- value$<$ 0.001). The estimated coefficients for *Money x Supergame* and *Memory x Supergame* are significantly different at the 1% level (p- value$<$ 0.001). The sum of the coefficients *Supergame* and *Memory x Supergame* is significant at the 10% level (p-value = 0.099). The sum of the coefficients *Supergame* and *Money x Supergame* is significant at the 1% level (p-value $<$ 0.001). *Controls* include the following individual characteristics: gender, major, two measures of understanding of the instructions (response time and number of wrong answers in the quiz) and session location (Purdue, Chapman).

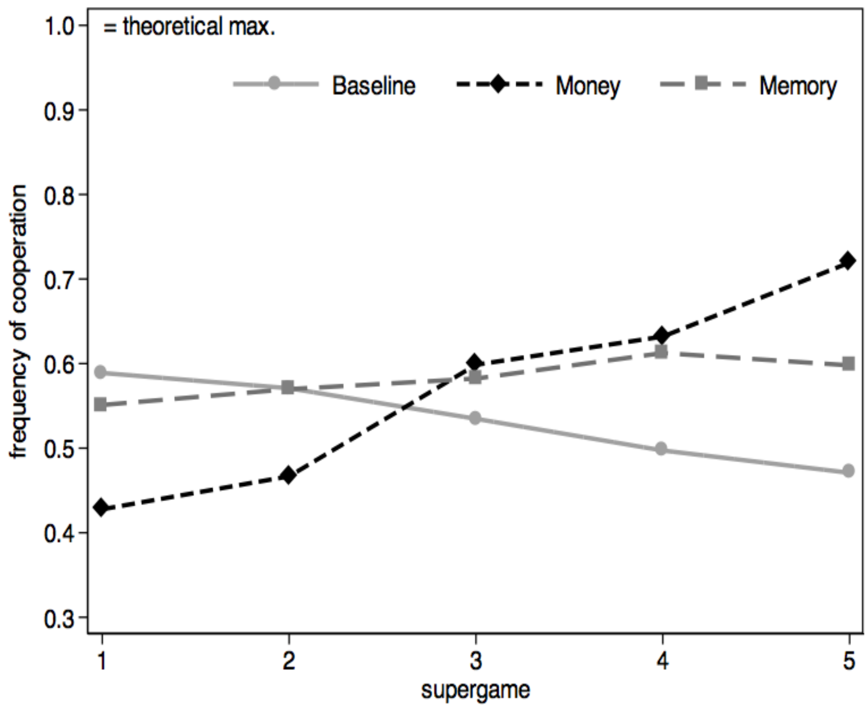

Figure 1: Cooperation frequency by treatment

One may conjecture that Money and Memory outperform the Baseline treatment because subjects have a habit of relying on record keeping and monetary exchange in everyday life. In fact, Money and Memory supported lower overall cooperation than Baseline in the short-run (Table 5). The lower performance of Money and Memory at the start of the sessions suggests that pre-existing habits of record keeping and monetary exchange are not the primary reason for the experimental results.

Result 3. *In the long-run* Money *supported higher cooperation and efficiency than* Memory.

Support for Result 3 is provided by Figure 1 and Tables 4-5. In the last supergame the average cooperation level in the Money treatment is significantly

Dependent variable:	Supergame 1		Supergame 5	
Individual frequency				
of cooperation	Estimate	S.E.	Estimate	S.E.
Money	-0.151*	0.069	0.307***	0.078
Memory	-0.059	0.065	0.132**	0.047
Constant	0.342*	0.155	0.456***	0.069
Controls	Yes		Yes	
N	240		240	
R-squared	0.212		0.207	

Table 5: Treatment Effects on Cooperation in Supergames 1 & 5.

Notes: One observation per subject. Inexperienced sessions. Standard errors (S.E.) robust for clustering at the session level. In supergame 1 the estimated coefficients for *Money* and *Memory* are significantly different at the 1% level (p-value: 0.002). In supergame 5 the estimated coefficients for *Money* and *Memory* are significantly different at the 5% level (p-value: 0.014). *Controls* include the following individual characteristics: gender, major, two measures of understanding of the instructions (response time and number of wrong answers in the quiz) and session location (Purdue, Chapman).

different from the Memory treatment (Table 5).

In the experiment, tokens became a fiat money in a manner consistent with monetary equilibrium. This finding about the endogenous emergence of monetary systems is in line with studies in Camera and Casari (2014); Camera et al. (2013). Tokens were by design intrinsically worthless, and—unlike the transfer of balances in the Memory treatment—their exchange was not forced. It is also important to note that tokens could be transferred in a way *opposite* to a pattern of monetary trade. Consumers could transfer a token conditionally on the producer *refusing* to help (Section 2). This type of behavior was not observed. Many producers actively offered help only in exchange for a token (63%) and consumers offered a token only in exchange for help (82%).[8] On the other hand, when consumers had no tokens to give, producers refused help

[8]These data refer only to encounters in which the exchange of tokens was feasible.

72% of the times.

One cannot exclude that the behavior in Memory is consistent with some equilibrium being played. Indeed, the design admits a continuum of equilibria, with frequencies of cooperation ranging from 0 to 100 percent due to public monitoring. What we do observe is that efficiency is lower in Memory than in Money even if subjects could easily adopt a trade strategy in both treatments. A possible explanation for Result 3 is that subjects were unable to exploit record-keeping to replicate a monetary trade pattern.

Result 4. Money *supported trade but* Memory *did not.*

Support for Result 4 comes from Figures 2-3 and Table 6. Full cooperation in Money and Memory can be achieved through trade as defined in the previous section. This means that after any history, in either treatment a producer with a low balance (=L) helps only a consumer with a high balance (=H). If everyone adopts this trade strategy, subject alternate deterministically between giving help and receiving help. Therefore, subjects would alternate between a balance of 0 as producers and 1 as consumers (Figure 2, left panel). In the experiment, the distribution of balances approximates the 50/50 theoretical distribution only in the Money treatment, where about 56% of subjects hold 0 tokens and 38% hold 1 token (Figure 2, center panel). This distributional pattern completely breaks down in the Memory treatment, where only 16% of subjects have a 0 balance and 23% have a unit balance (Figure 2, right panel).

Another indicator of the adoption of the trade strategy is provided in Figure 3. The trade strategy implies that help should be given in every equilibrium encounter. However, this is not so off-equilibrium, where help should be given only in some encounters but not in others. The trade strategy implies that

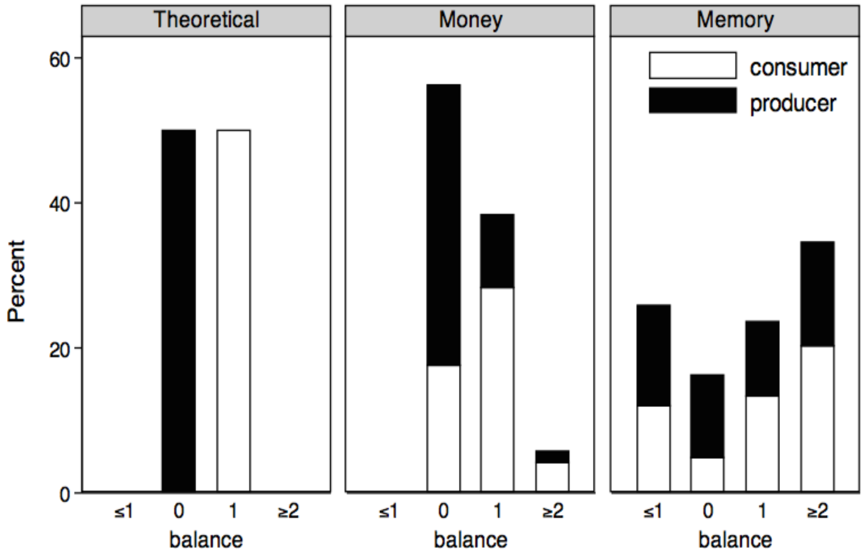

Figure 2: Distribution of balances in Money and Memory

Notes: Based on periods 15-20 of each supergame.

help should be given only in *trade meetings*, where the producer's balance is L and the consumer's is H, and should not be given in all other meetings and, in particular, if consumers have balance L. Figure 3 shows the empirical frequency of cooperation when help should and should not be given according to the trade strategy (solid vs. dashed line). Theoretically, the solid line should be at 100%, and the dashed line at 0%, if everyone followed the trade strategy. In the Money treatment (Figure 3, left panel), the aggregate cooperation frequency is consistent with the widespread adoption of the trade strategy: the distance between the two lines in Figure 2, solid vs. dashed, amounts to 49 percentage points in the last supergame. No such evidence emerged in Memory treatment, where there is a minimal difference between lines, even in the last supergame (1 percentage point, Figure 3, right panel).

The data reveal that subjects do not use record-keeping in the same manner

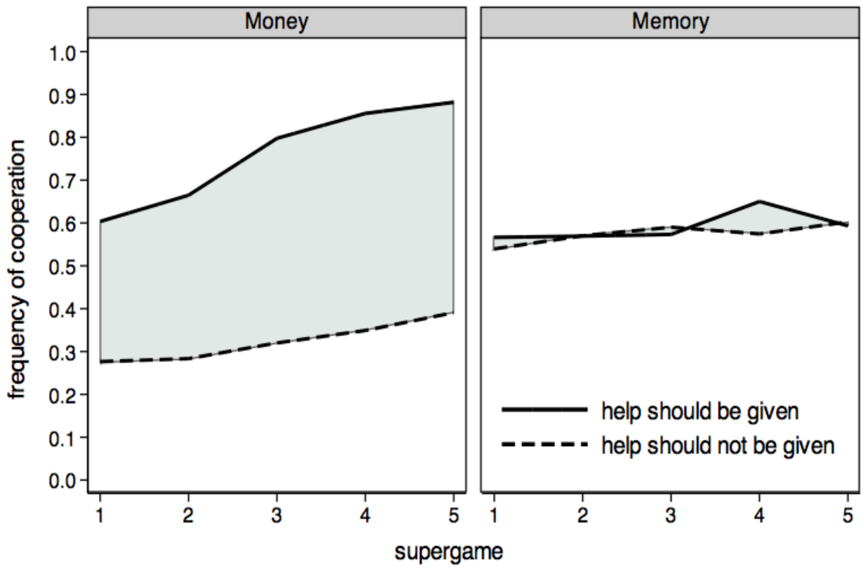

Figure 3: Trade emerges in MONEY but not in MEMORY.

they use tokens. Producers do help more frequently consumers with balance H rather than L. However, in MEMORY producers do not condition their help on their own balance as they should following a trade strategy, while in MONEY they do, helping more frequently if *their* balance is L rather than H.

Table 6 reports the marginal effects of balances in a pair on the probability of observing cooperation in the pair, in the two treatments. If subjects adopt the trade strategy in each treatment, then the probability of observing cooperation should be higher in *trade meetings*—where the producer's balance is L and the consumer's is H—than in all other meetings. The MONEY treatment is in line with this prediction: we observe that the probability of observing help being given is significantly higher in trade meetings than in all others (p-value < 0.001 for all comparisons). However, this is not so in MEMORY, where the estimated marginal effect of being in a trade meeting is significantly smaller than the estimated marginal effect when both producer and consumer have balance H (p-value = 0.003). In addition, the estimated marginal effect of being in a trade meeting is much smaller in Memory than in Money (p-value < 0.001 according to a regression with pooled data from both treatments). This is evidence that the trade strategy is used in Money but not in Memory.

Dependent variable: *Cooperation outcome in a pair*	Money Estimate	Money S. E.	Memory Estimate	Memory S. E.
Supergame	0.099***	0.016	0.138***	0.029
Period	-0.002***	0.001	-0.005***	0.002
Balance				
Producer, Consumer				
L, H	0.440***	0.035	0.095***	0.016
H, L	-0.118**	0.055	-0.006	0.032
H, H	0.203***	0.063	0.191***	0.024
Controls	Yes		Yes	
N. of obs. (N. of subjects)	3600 (72)		4800 (96)	

Table 6: How the balances in a meeting affect cooperation.

Notes: One observation per subject per period. Inexperienced sessions. Marginal effects from a logit regression. Standard errors (S.E.) robust for clustering at the session level. *Controls* include the following individual characteristics: gender, major, two measures of understanding of the instructions (response time and number of wrong answers in the quiz) and session location (Purdue, Chapman).

Result 5. Money *removed the incentives to free ride but* Memory *did not.*

Support for Result 5 comes from Figure 4. The introduction of Money and Memory altered the distribution of earnings because it redistributed surplus from frequent defectors to frequent cooperators (Figure 4). In each supergame, we classified subjects into five categories according to the frequency of cooperative outcomes in periods in which they were producers (horizontal axis) and computed the associated average earnings across all periods, regardless of their role, consumer or producer (vertical axis). In Baseline, about 39% of subjects are frequent cooperators and 28% are frequent defectors; those who earned the most on average are the frequent defectors (Figure 4, solid line). Introducing the record keeping technology lowered the incentives to defect relative to cooperation. The association between income and cooperation remained U-shaped and frequent defectors still earn the most (Figure 4, dashed line with squares). In contrast, the use of tokens as money generates a dramatic shift in incentives: average individual earnings and cooperation frequency exhibit a positive, monotone association (Figure 4, dashed line with diamonds). Frequent defectors are now the category that earned the least, and account for only 8% of the subject population.[9] In short, a monetary system endogenously emerged in the Money treatment and the use of money removed the incentives to free ride. In contrast, in the Memory treatment subjects failed to remove incentives to free-ride, which is a likely reason why efficiency is lower in Memory than in Money.

Experience with the task is relevant for cooperation frequency, as Figure 1 suggests. One open question is, therefore, whether Memory could outperform Money in cooperation frequency if subjects had already gained enough experience. All of the results above are based on the behavior of subjects that had no previous experience with the game. Result 6 below, instead, presents evidence from subjects who already participated in a previous session of the same treatment.

Result 6. *The behavior of experienced subjects confirms and reinforces Results 1-5.*

Support for Result 6 is in Appendix B and is based on sessions where subjects had previously participated in an experiment under the same treatment.

[9]This result confirms previous findings reported in (Camera and Casari, 2014)

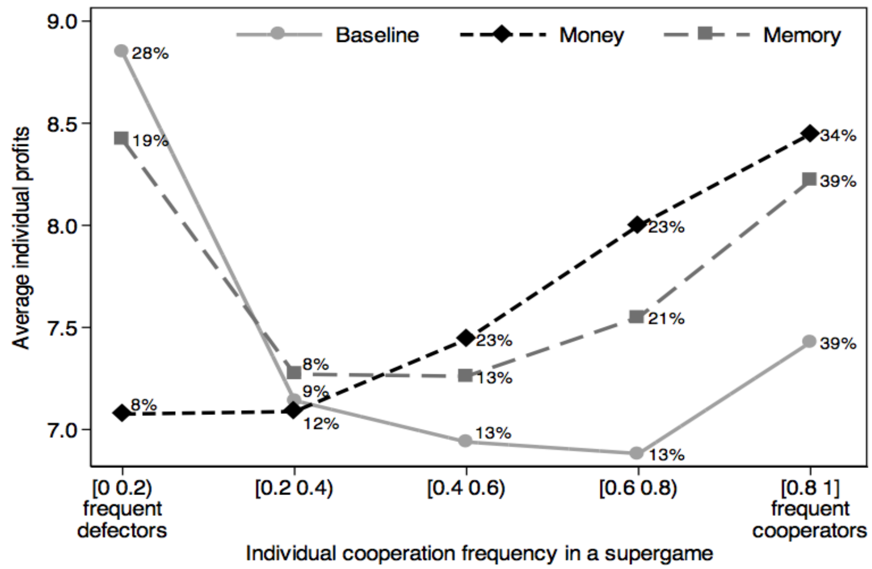

Figure 4: Cooperation frequency and profits

Notes: The percentages show the share of subjects in each category by treatment.

By the last supergame of the experienced sessions, cooperation in Baseline had fallen to 28.8%, in Money had risen to 94.6%, and in Memory had reached 55.4%. These levels are significantly different one from another according to a probit regression (see Appendix B). These additional data confirm and reinforce Results 1, 2 and 3.

Experience with the task helps to firmly establish the use of trade strategy in Money but not in Memory, which strengthens the finding for inexperienced subjects (Result 4). Consider the distance between the solid and dashed lines in a graph made with data from experienced sessions and similar to Figure 3. By the last supergame, there was a distance of 85 percentage points in Money and of 8 points in Memory (see Appendix B). Experience also wiped out free riding behavior in Money in line with Result 5 for inexperienced subjects. About 89% of subjects were frequent cooperators and there was nobody with an average cooperation rate less than 40%.

5 Related studies

Our work is related to experimental studies of cooperation in repeated social dilemmas and, in particular, to indefinitely repeated dilemmas—which support a richer set of equilibria compared to games that are one-shot or with a commonly known number of periods (Dal Bó, 2005; Palfrey, 1994). These related studies differ in the type of stage game, matching protocol, and informational conditions that are considered.

Most of the experiments on indefinitely repeated games have focused on tasks in which all subjects make a decision in every period, e.g., prisoners' dilemmas, voluntary contribution mechanisms, Bertrand duopolies, or trust games (see Bigoni et al., 2012; Engle-Warnick and Slonim, 2006; Kurzban and Houser, 2005; Roth and Murnighan, 1978). In contrast, the stage game in our design is a cooperative task known as helping or gift-giving game, in which one subject makes a decision and the other is passive (Nowak and Sigmund, 1998). The game is at the core of a large class of decentralized trade models in macroeconomics (Kocherlakota, 1998). The task is simple and directs subjects' attention to the possibility of an intertemporal exchange of favors, which is at the core of the present study.

The typical matching protocol in indefinitely repeated experiments involves fixed pairs (e.g., Dal Bó and Fréchette, 2011), which is suitable to study cooperation in small societies, where interaction is characterized by repeated encounters with known individuals. Instead, we adopt a strangers' matching protocol, which prevents subjects from relying on direct or indirect reciprocity. Such protocol allows us to study institutions that promote large-scale cooperation, which is central to understanding outcomes in contemporary societies where there is less scope for reciprocity because social interactions are fragmented. There is a related literature on this theme, which has mostly focused on personal punishment and information-sharing institutions such as communication (Camera and Casari, 2009; Cooper and Kuhn, 2014). Our unique contribution is to concentrate on the institution of money.

Our paper studies how knowledge of others' past actions affects trust and cooperation in a helping game. A correspondence exists with the literature on scoring systems, which mostly adopts helping games, albeit with a known ending.[10] The information-sharing system generally adopted in this literature differs from the one we implement in the MEMORY treatment along several dimensions. First, agents can observe a summary of only the most recent decisions of their opponents (e.g., Ule et al, 2009); we instead give a summary of *all* past decisions of opponents. Second, scores typically account only for the help given, ignoring the help *received*—unlike our experiment. Third, our design differs from experiments on "second order" information (e.g., Bolton et al., 2005; Milinski et al, 2001) because the information summaries provided in our experiment are not designed to reveal possible motives behind an agent's refusal to help (e.g., to discover if it is a reaction to defections by someone else). Finally, in our experiment information-sharing systems cannot augment subjects' ability to recall past decisions (Basu et al., 2009), as it is already perfectly accurate.

By studying indefinitely repeated games where subjects may exchange sym-

[10]There is also a literature that has adopted indefinite horizon games of a different type, mostly prisoners' dilemmas or trust games to study the connection between knowledge of opponents' histories and cooperation (e.g., Bohnet and Huck, 2004; Camera and Casari, 2009). A hybrid design is in Offerman et al (2001), where subjects plays a one-shot, one-side giving problem, in a sequence of unknown length.

bolic objects we contribute to an experimental literature about the endogenous emergence of fiat monetary systems (Camera and Casari, 2014; Camera et al., 2013). We have built upon these earlier studies and modified the design to offer a direct test of the theoretical assertion that the fundamental role of money in a society is to reveal past behaviors. Such a test represents a unique contribution to monetary economics and also to an experimental literature on fiat money (e.g. Deck et al, 2006; McCabe, 1989).[11]

6 Discussion and conclusion

At the heart of economics lies the notion that specialization and trade hold the key to economic development. Yet, broadening the scope of commerce from a personal to an impersonal domain presents hurdles because reputation, trust and other motivational mechanisms can no longer be leveraged to deter opportunistic behaviors. Many institutions have emerged over the course of history to assist impersonal exchange (Greif, 2006; North, 1991; Ostrom, 2010), including money, which remains "the universal instrument of commerce" today much as it was more than two centuries ago when Adam Smith wrote those words (Smith, 1776, Chapter 4).

Through an experiment, we have analyzed the behavioral role of money in comparison to an institution for maintaining and sharing information about past conduct, which monetary economists call "memory." Theory asserts that money has no role to play when individuals can rely on shared knowledge of past conduct to reproduce patterns of monetary exchange (Kocherlakota, 1998; Townsend, 1987). We constructed economies in which strangers—who by design cannot engage in relational contracting—can derive significant benefits

[11] See Camera and Casari (2014) for a review of the experimental literature on money and more details on the designs in other experiments.

from cooperating over the long haul. We find that the suggested theoretical affinity between money and memory does not empirically translate into a functional equality. The differences in long-run efficiency, strategies and distribution of earnings in the Money and Memory treatments demonstrate that money performs a richer set of functions than just revealing past behaviors.

Cooperation was significantly greater in Money compared to Memory, a difference that becomes increasingly evident as subjects gain experience. In both treatments subjects conditioned their choice to help others on balances in their pair, but did so in a dissimilar manner. In Memory, many producers helped even when their own balance was already positive, which set the wrong incentives for free riders—who continued to behave opportunistically. On the contrary, this pattern is rare in Money, and this was instrumental to its success.

At the heart of this finding lies a crucial inability to coordinate on collective punishment schemes in groups of strangers. This is already evident in the Baseline treatment (Result 1) where subjects observe whether there are free-riders in the group without being able to identify them. Cooperation can be self-enforcing only if the group adopts a *common* punishment scheme, but groups seem unable (or unwilling) to do so, possibly due to heterogeneity in beliefs, cognitive skills, or emotional reactions. The addition of record-keeping in Memory lessens this fundamental behavioral problem (Result 2) by providing individual-specific information on past conduct, but does not fully solve it. Subjects *can* identify individuals as being free-riders—based on their balances—but still do not consistently sanction them (Result 5). The exchange of tokens in Money bypasses this coordination issue because punishment is built into the system (Result 4), as we explain next.

Subjects could adopt identical strategies in Money and Memory, but did not. In MONEY cooperation was based on monetary trade, which is self-enforcing by design. A producer has an incentive to help for a token—to avoid being "liquidity constrained" in the future—and has nothing to gain from helping free-riders, who have nothing to offer in exchange. This contrasts with the record-keeping system in MEMORY because opportunistic consumers can always "pay" by accumulating negative balances. Here, cooperation is self-enforcing if no producer helps such opportunistic individuals, yet there is a temptation to do so because the producer "gets paid" after all. A failure to punish is the source of a negative externality, which magnifies free riders' opportunistic motivations and displaces cooperation. In MEMORY, subjects failed to fully appreciate such externality and often failed to punish. Instead, token exchange in MONEY internalized this externality. As a result—although liquidity constraints are generally considered a source of inefficiency—relaxing them in the experiment (as we do in MEMORY) lowers long-run efficiency (Result 3). In our laboratory economies liquidity constraints impose discipline on sanctioning behavior, which channels the group toward cooperation.

The findings suggest that in order to bypass the hurdle of coordinating on a sanctioning rule, one must introduce institutions *in addition* to record-keeping. For example, consider a system that updates balances *only if* the producer helps when she should, i.e., when meeting a consumer with a positive balance. Such *ad-hoc* manipulation of action histories would amount to *imposing* a form of monetary trade. In contrast, in the MONEY treatment the institution of monetary trade emerges endogenously, it is neither imposed nor based on ad-hoc manipulation of histories.

Could more extensive public records bring cooperation in MEMORY closer to the levels observed in MONEY? A broader information disclosure, such as making public all identities and all past actions, is known to have a powerful behavioral effect on cooperation because it enables relational contracting (e.g., Camera and Casari, 2009). But such disclosure would fundamentally change the nature of this study, which is to take on the bigger challenge of investigating how to sustain cooperation among *strangers*, when relational contracts are unavailable. The design supplies public information at a level that equally supports full cooperation in all treatments—without the need of additional institutions—while carefully ensuring that interactions remain impersonal. Subjects are informed whether someone defected in their group, without being able to single the offender out. Record-keeping augments this anonymous public monitoring system with a summary of the opponent's past history in the form of a concise balance (L or H); according to theory, this is sufficient to facilitate cooperation by replicating a monetary trade pattern, while maintaining interaction impersonal. An alternative design with precise numeric balances has the drawback of allowing identification of past opponents—altering the nature of the interaction from impersonal to personal.

The experimental evidence provided here reinforces the long-held view that monetary systems are fundamental to support impersonal exchange, intertemporal trade and, consequently, large-scale cooperation (Hayek, 1991; Smith, 1776). It also highlights original aspects of the institution of money that were previously ignored or little understood. The analysis demonstrates that the use of money imposes a discipline on what agents are willing to do in order to keep the economy on a cooperative track. Such findings suggest that well-functioning monetary systems are not simply rudimentary arrangements for monitoring past conduct in society, but play a richer role than previously thought.

References

Basu, S., Dickhaut, J., Hecht, G., Towry, K., and Waymire, G. 2009. Record-keeping alters economic history by promoting reciprocity. *Proceedings of the National Academy of Sciences*, 106(4), 1009-1014.

Bigoni, M., Fridolfsson, S. O., Le Coq, C., and Spagnolo, G. 2012. Fines, Leniency and Rewards in Antitrust. *The RAND Journal of Economics*, 43(2), 368-390.

Binmore, K. 2005. *Natural Justice*, Oxford University Press.

Bohnet, I. and Huck, S. 2004. Repetition and reputation: Implications for trust and trustworthiness when institutions change. *The American Economic Review*, 94(2), 362-366.

Bolton, G. E., Katok, E., and Ockenfels, A. 2005. Cooperation among strangers with limited information about reputation. *Journal of Public Economics*, 89(8), 1457-1468.

Bowles, S. and Gintis, H., 2011. *A Cooperative Species: human reciprocity and its evolution*. Princeton University Press.

Camera, G. and Casari, M. 2009. Cooperation among strangers under the shadow of the future. *The American Economic Review*, 99(3), 979-1005.

Camera, G. and Casari, M. 2014. The Coordination Value of Monetary Exchange: Experimental Evidence. *American Economic Journal: Microeconomics*, 6(1), 290-314.

Camera, G., Casari, M., and Bigoni, M. 2013. Money and trust among strangers. *Proceedings of the National Academy of Sciences*, 110(37), 14889-14893.

Cooper, D. J. and Kuhn, K.-U. 2014. Communication, Renegotiation, and the Scope for Collusion. *American Economic Journal: Microeconomics*, 6(2), 247-78.

Corbae, D. Temzelides, T. and Wright, R. 2003. Directed matching and monetary exchange. *Econometrica*, 71 (3), 731-756.

Dal Bó, P. 2005. Cooperation under the Shadow of the Future: Experimental Evidence from Infinitely Repeated Games. *American Economic Review*, 95(5), 1591-1604.

Dal Bó, P. and Fréchette, G. 2011. The Evolution of Cooperation in Infinitely Repeated Games: Experimental Evidence. *American Economic Review*, 101(1), 411-429.

Deck, C. A., McCabe, K. A., and Porter, D. P. 2006. Why stable fiat money hyperinflates: Results from an experimental economy. *Journal of Economic Behavior & Organization*, 61(3), 471-486.

Engle-Warnick, J. and Slonim, R. L. 2006. Learning to trust in indefinitely repeated games. *Games and Economic Behavior*, 54(1), 95-114.

Greif, Avner. 2006. The Birth of Impersonal Exchange: The Community Responsibility System and Impartial Justice. *Journal of Economic Perspectives*, 20(2), 221-236.

Hayek, F.A. *The Fatal Conceit: The Errors of Socialism*. The University of Chicago Press, (1991).

Kimbrough Erik O., Smith Vernon and Wilson, Bart J. 2008. Historical Property Rights, Sociality, and the Emergence of Impersonal Exchange in Long-Distance Trade. *American Economic Review*, 98(3), 1009-1039

Kiyotaki, Nobuhiro, and Randall Wright. 1989. On Money as a Medium of Exchange. *Journal of Political Economy*, 97, 927-954.

Kocherlakota, N.R., 1998. Money is memory. Journal of Economic Theory, 81, 232-251.

Kranton, Rachel E. 1996. Reciprocal Exchange: A Self-Sustaining System. *American Economic Review*, 86(4), 830-51.

Krugman, Paul. 2013. Bitcoin is Evil. *New York Times*, December 28^{th} edition.

Kurzban, R. and Houser, D. 2005. Experiments investigating cooperative types in humans: A complement to evolutionary theory and simulations. *Proceedings of the National Academy of Sciences*, 102(5), 1803-1807.

McCabe, K. A. 1989. Fiat money as a store of value in an experimental market. *Journal of Economic Behavior & Organization*, 12(2), 215-231.

McCabe, K., Rassenti, S., and Smith, V., 1998. Game Theory and Reciprocity in Some Extensive Form Experimental Games. *Proceedings National Academy of Science*, 93, 13421-13428.

Milinski, M., Semmann, D., Bakker, T. C., and Krambeck, H. J. 2001. Cooperation through indirect reciprocity: image scoring or standing strategy? *Proceedings of the Royal Society of London, Series B: Biological Sciences*, 268, 2495-2501.

New York Times. 2011. Whispers of Return to Drachma Grow Louder in Greek Crisis. By Landon, T., November 1^{st} edition.

North, D.C., 1991. Institutions. *Journal of Economic Perspectives*, 5(1), 97-112.

Nowak, M. A. and Sigmund, K. 1998. Evolution of indirect reciprocity by image scoring. *Nature*, 393(6685), 573-577.

Offerman, T., Potters, J., and Verbon, H. A. 2001. Cooperation in an overlapping generations experiment. *Games and Economic Behavior*, 36(2), 264-275.

Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems. *American Economic Review* 100, 641-672.

Ostroy, J.M. 1973. The Informational Efficiency of Monetary Exchange. emphAmerican Economic Review, 63(4), 597-610

Palfrey, T.R. and Rosenthal, H., 1994. Repeated Play, Cooperation and Coordination: An Experimental Study. *The Review of Economic Studies*, 61(3), 545-565.

Roth, Alvin E., and Keith Murnighan. 1978. Equilibrium behavior and repeated play of the prisoner's dilemma. *Journal of Mathematical Psychology*, 17, 189-98

Smith, Adam, 1776. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Gateway Editions; First Edition edition (September 1, 1999)

Townsend, R., 1987. Economic Organization with Limited Communication. *American Economic Review*, 77 (5), 954-971

Ule, A., Schram, A., Riedl, A., and Cason, T. N. 2009. Indirect punishment and generosity toward strangers. Science, 326(5960), 1701–1704.

Wedekind, C. and Milinski, M. 2000. Cooperation through image scoring in humans. *Science*, 288(5467):850–852.

CENTER FOR FINANCIAL STUDIES

CFS Working Paper Series

Recent Issues

All CFS Working Papers are available at *www.ifk-cfs.de*.

No.	Authors	Title
495	Ronald Bosman, Roman Kräussl, Thomas van Galen	*Emotions-at-Risk: An Experimental Investigation into Emotions, Option Prices and Risk Perception*
494	Roman Kräussl	*Art as an Alternative Asset Class: Risk and Return Characteristics of the Middle Eastern & Northern African Art Markets*
493	Roman Kräussl, Thorsten Lehnert, Nicolas Martelin	*Is There a Bubble in the Art Market?*
492	Roman Kräussl, Elizaveta Mirgorodskaya	*News Media Sentiment and Investor Behavior*
491	Jill E. Fisch	*The Broken Buck Stops Here: Embracing Sponsor Support in Money Market Fund Reform*
490	Hans A. Holter, Dirk Krueger, Serhiy Stepanchuk	*How Does Tax Progressivity and Household Heterogeneity Affect Laffer Curves?*
489	Sylwia Hubar, Christos Koulovatianos, Jian Li	*Fitting Parsimonious Household-Portfolio Models to Data*
488	Dimitris Christelis, Dimitris Georgarakos, Anna Sanz-de-Galdeano	*The Impact of Health Insurance on Stockholding: A Regression Discontinuity Approach*
487	Lutz Hendricks, Oksana Leukhina	*The Return to College: Selection and Dropout Risk*