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Game-theoretic foundations of monetary equilibrium

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ABSTRACT

According to theory, money supports trade in a world without enforcement and, in particular, in large societies, where gift-exchange is unsustainable. It is demonstrated that, in fact, monetary equilibrium breaks down in the absence of adequate enforcement institutions and it collapses as societies that lack external enforcement grow large. This unique result is derived by unveiling the existence of a tacit enforcement assumption in the literature that explains the advantages from monetary exchange, and by integrating monetary theory with the theory of repeated games and social norms.

1. Introduction

Why do societies rely on money? According to theory, the advantage of money is that, by exchanging it, trade can be supported in the absence of enforcement institutions. Put differently, by relying on money individuals are able to outperform equilibria based on rules of *voluntary* behavior (Huggett and Krasa, 1996; Kocherlakota, 1998; Araujo, 2004).

To develop this idea, imagine a group of anonymous individuals (or strangers) who face repeated opportunities to help others, at a cost. Payoffs are maximized if everyone helps others and minimized if no one helps. If individuals cannot self-commit to actions and external enforcement is unavailable, then they may not trust that help today will be later returned by others, in which case a norm of mutual support may not emerge. Monetary theorists argue that a way to solve this problem is to exchange help for (fiat) money. Yet, the theory leaves open a crucial question. What incentives does monetary exchange provide to help others that norms of voluntary behavior cannot reproduce?

To look into this issue, this paper studies monetary equilibrium by adopting analysis techniques from the literature on repeated matching games (Kandori, 1992; Ellison, 1994). The main findings can be summarized as follows. First, this study unveils the existence of a tacit enforcement assumption in the literature that explains the advantages of monetary exchange. Second, by applying a method of analysis developed in a companion paper (Camera and Gioffré, 2013), this study demonstrates that, in fact, monetary equilibrium cannot be sustained without adequate enforcement institutions. In particular, as societies grow large, monetary equilibrium collapses in the absence of some basic form of external enforcement: the enforcement of property rights.

In the model, a stable population of anonymous players is randomly divided in pairs in each period. In every encounter one subject can provide a benefit to the other by sustaining a small cost (=make a voluntary transfer). This interaction is

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infinitely repeated (Camera et al., 2013; Camera and Casari, 2014). Since players cannot build reputations and cannot adopt relational contracts, there is an incentive to behave opportunistically and avoid making transfers. May the introduction of symbolic objects (=tokens) support an outcome that is socially preferred?

Monetary theorists have offered a positive answer by imposing *quid-pro-quo* constraints: any transfer requires a concurrent payment, or else it fails.[1] In a simultaneous-moves game this amounts to assuming away any temptation to defect (=give nothing) by imposing mechanical punishment (=get nothing), so if money has value, monetary trade is incentive-compatible by design. *Quid-pro-quo* is a form of external enforcement—enforcement of property rights perhaps—which converts the underlying social dilemma into a coordination game by restricting the outcome set.

What if one does not restrict outcomes in a match? The Folk-theorem type results in Kandori (1992) and Ellison (1994) indicate that, in sequential equilibrium, opportunistic behavior must be deterred with proper dynamic incentives or otherwise players might not voluntarily deliver their "quid," even if they get the "quo." Now, money no longer sustains exchange without enforcement—external or not—and in particular is no longer capable of providing sufficient incentives to trade if the economy is sufficiently large.

Our finding that money cannot support trade without adequate enforcement is unique. It is meaningful because it provides a theoretical foundation for the notion that monetary exchange cannot operate as a stand-alone institution to overcome trade frictions. Simply put, the option to exchange symbolic objects for goods does not per se remove the opportunistic temptations that inhibit cooperation and trade in societies of strangers. In such societies, individuals do not have high levels of information about others' past behavior and so basic enforcement institutions must be developed in order for trade to flourish (North, 1991). This leads us to hypothesize that the monitoring difficulties due to the growth in size of human settlements, over the course of history, might have provided a push towards adoption of monetary exchange only in those communities equipped with effective institutions for the enforcement of basic property rights.[2]

The paper proceeds as follows. Section 2 presents the model and reports the main theorem, which is proved in Section 3. Section 4 offers some final remarks.

2. A model of intertemporal exchange

Consider an economy populated by $N=2n\geq 4$ infinitely-lived agents who face a social dilemma (Camera and Casari, 2014; Camera et al., 2013). An exogenous matching process partitions the population into n pairs in each period $t=0,1,\ldots$. Pairings are random, equally likely, independent over time, and last only one period. Let $o_i(t)\neq i$ be agent i's opponent (or partner) in period t.

In each pair $\{i,o_i(t)\}$, a coin flip assigns the role of *buyer* to one agent, and *seller* to the other. Hence, in each period an agent is equally likely to either be a seller meeting a buyer, or a buyer meeting a seller. The buyer has no action to take. The seller can choose C or D; C is interpreted voluntarily transferring a good; Fig. 1 reports the payoff matrix, where $g-d-l>0$ and $-l\leq 0\leq d<g$.[3]

The outcome C is called *gift-giving*: the buyer earns surplus $g-d$ and the seller's surplus loss is $-l$. The outcome D is called *autarky*, as it generates no trade surplus. Define the (socially) efficient outcome in a match as the one in which, giving equal weight to players, total surplus is maximized. Gift-giving is efficient, because $g-d-l>0$, but is *not* mutually beneficial, because buyers benefit at the expense of sellers. Autarky is the unique Nash equilibrium of a one-shot interaction.

Now consider infinite repetition of such interaction. It is assumed that, in each t, each agent in $\{i,o_i(t)\}$, for $i=1,\ldots,N$, observes only the outcome in their match (=private monitoring). The identity of $o_i(t)$ and the outcome in other pairs are unobservable, so players cannot recognize past opponents if they meet them again (=anonymity). These assumptions imply that agents can neither build a reputation nor engage in relational contracting—a standard assumption in monetary theory.

Payoffs in the repeated game are the sum of period-payoffs, discounted by a common factor $\beta\in[0,1)$.[4] In the repeated game, the efficient outcome corresponds to the one in which total surplus is maximized in each match, and in each period. This outcome is called "gift-giving" because it involves an infinite sequence of unilateral transfers.

Consider a strategy described by a two-state automaton with states "active" and "idle." The agent takes actions only as a seller. At the start of any date, if seller i is active, he selects C, and otherwise D. Agent i is active on date $t=0$, and in all $t\geq 1$ (i) if agent i is active, then i becomes idle in $t+1$ only if the seller in $\{i,o_i(t)\}$ chooses D. Otherwise, agent i remains active; (ii) there is no exit from the idle state. If everyone adopts this strategy, then the entire group participates in enforcing defections, and gift-giving is a sequential equilibrium if N is sufficiently small (Araujo, 2004). Otherwise, community enforcement does not represent a sufficient deterrent (Kandori, 1992; Ellison, 1994). So, let us add fiat money to study if its use can solve such enforcement problems.

[1] For instance, consider the "no-commitment trading mechanism" assumed in Kocherlakota (1998), which embeds a technology that filters out outcomes that are not mutually desirable. For a discussion of *quid-pro-quo* constraints see Starr (1972) or Ostroy and Starr (1990).

[2] How do such institutions emerge and how do they affect the process of exchange? The work in Kimbrough et al. (2008, 2010) offers some intriguing empirical evidence on this important open question.

[3] E.g., sellers have a perishable good, and buyers derive greater utility than sellers from consuming goods.

[4] Equivalently, let the economy be of *indefinite* duration where β is the time-invariant probability that, after each period the economy continues for one additional period, while with probability $1-\beta$, the economy ends.