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Limited monitoring and the essentiality of money

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ABSTRACT

Monetary theory emphasizes that imperfect monitoring is necessary for money to be essential, that is, for money to achieve socially desirable allocations. Little is known about how limited monitoring must be if money is to be essential, though. Understanding sufficient conditions for the essentiality of money is important since monitoring is a natural way in which credit is introduced in monetary models. In this paper, we show that money can fail to be essential even if monitoring is quite limited. This indicates that one must be careful when introducing monitoring in monetary models to allow for the coexistence of money and credit.

1. Introduction

Money is essential if socially desirable allocations can only be achieved with its use. It is well-known that imperfect monitoring, that is, the fact that individual histories are imperfectly observed, is necessary for the essentiality of money. Money is not essential if monitoring is perfect because the information about past histories conveyed by money is redundant if past histories can be perfectly observed (Kocherlakota, 1998). On the other hand, much less is known about how limited monitoring must be if money is to be essential. Wallace (2014) summarizes this state of affairs as follows: "There are, however, no general necessary and sufficient conditions for essentiality of money. In particular, imperfect monitoring is not sufficient to give a role for money. Therefore, it is not surprising that many models contain extreme sufficient conditions to ensure that money is essential" (pp. 259–260).[1] Understanding the restrictions one needs to impose on monitoring in order to preserve the essentiality of money is important, though, as the introduction of credit in monetary models usually requires a monitoring technology, and one needs to be careful to prevent the monitoring technology that enables credit from making money irrelevant.

In this paper we show that the first-best can be achieved without money if monitoring is such that in every meeting an agent observes *only* the last period action of his partner and the preferences of the last period partner of his partner. This is much less information than the information contained in the record-keeping notions previously considered in the literature. We conduct our analysis in a class of environments that allows for heterogeneous utility functions and includes the standard random matching, overlapping generations, and turnpike environments as special cases.

There are two messages to be taken from our non-essentiality result. First, since it significantly relaxes the requirements on monitoring needed to implement the first-best, our non-essentiality result suggests that the extreme sufficient conditions usually made in the literature to ensure that money is essential are warranted. This is bad news if one wants to build coherent models where money-like and credit-like instruments coexist and are both relevant.[2] Second, our non-essentiality result calls for a more careful look at the notions of limited monitoring used by monetary theorists. This is good news if one believes that a better understanding of the details of monitoring technologies leads to better models of money and credit.

The rest of the paper is organized as follows. We discuss the related literature in the remainder of this section and describe our setting in the next section. We prove our non-essentiality result in

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[1] Examples of models which make extreme assumptions about (the absence of) monitoring to ensure the essentiality of money are Kiyotaki and Wright (1993), Trejos and Wright (1995), Shi (1995, 1997), and Lagos and Wright (2005).

[2] Recently, a number of papers based on Lagos and Wright (2005) introduce monitoring and allow for both money and credit to mediate transactions. These papers, however, focus on the existence of equilibria in which money and credit coexist without paying too much attention to the coessentiality of these instruments. Examples are Telyukova and Wright (2008), Sanches and Williamson (2010), and Williamson (2012). A recent paper making the point that coessentiality of money and credit is difficult to achieve is Gu et al. (2014).

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Section 3 and discuss its robustness in Section 4. We conclude in Section 5.

Related literature

Kocherlakota (1998) considers a monitoring technology, which he calls memory, that allows agents to observe the past histories of their direct and indirect partners, and shows that any allocation that can be achieved with money can also be achieved with memory. Our monitoring technology is structured as in Kocherlakota (1998) except that it allows agents to observe only a subset of the information they observe in Kocherlakota (1998), namely, their partner's last period action and partner preferences. Our main result is that this information is enough to implement the first-best. Intuitively, this information allows agents to observe the context of the last period meeting of their partners, which is sufficient for an agent to verify whether his current partner produced the efficient quantity to his previous period partner. Thus, almost all the information contained in Kocherlakota's (1998) monitoring technology, while necessary to replicate the set of monetary allocations, is not necessary to achieve socially desirable allocations.

The literature on the relationship between monitoring and the essentiality of money has considered other notions of record-keeping besides the notion introduced in Kocherlakota (1998). Kocherlakota and Wallace (1998) consider a monitoring technology in which the private histories of all agents in the economy are publicly revealed with a lag, so that one does not need to meet an agent in order to observe his private history. Cavalcanti and Wallace (1999a,b) consider a variant of this technology in which only a subset of the agents in the population can have their private histories revealed, but the revelation occurs without a lag.[3] The monitoring technologies in both of these papers feature a coordination component that is absent from the monitoring technology that we consider. In fact, public revelation of private histories allows agents to coordinate on extreme punishments, such as global autarky, something that is not possible when agents can observe only the private histories of the agents they meet.

Our paper is also related to the literature that studies how social norms can be enforced in random matching environments. Kandori (1992) is the seminal reference in this literature. The papers in this literature most closely related to ours are Araujo (2004), Aliprantis et al. (2007), and Takahashi (2010). Araujo (2004) shows that even without record-keeping, a gift-giving social norm can substitute the use of money as long as the population is finite and agents are patient enough. Aliprantis et al. (2007) show that the presence of centralized trade can help sustain a social norm that leads to efficient non-monetary trade even in large populations and discuss how this result can be overturned by suitably changing the matching process in the centralized market.[4] Takahashi (2010) studies community enforcement in a large population in which in every period individuals are randomly and anonymously matched in pairs to play a prisoner's dilemma game and shows that if agents are patient enough, cooperation can be sustained by a belief-free equilibrium as long as players can observe their (direct) partners' past play.[5] We extend Takahashi's analysis to our richer environment, which allows for heterogeneous agents and for a more general matching technology.[6]

2. Setting

We first describe the (physical) environment and preferences. Then we introduce our monitoring technology and define equilibria.

2.1. Environment and preferences

Time is discrete and indexed by $t \geq 1$. There exist a continuum of non-atomic agents, that we identify with the interval $[0, 1]$, and a countable set Ω of agent types. For each $\omega \in \Omega$, there exists a positive mass of agents who are of type ω. Different types of agents can live for different lengths of time and in different periods. Let $N(\omega)$ be the set of periods in which the agents of type ω are alive. Preferences are additively separable over time and all agents have the same discount factor $\beta \in (0, 1)$. We normalize payoffs by $1-\beta$.

Agents can trade a divisible and perishable good that comes in many varieties. There exists one variety of the good for each type of agent. An agent of type ω can produce only the variety of type ω and likes to consume a variety of type ω' only if $\omega' \in \lambda(\omega)$, where $\lambda : \Omega \rightrightarrows \Omega$ is a correspondence such that $\omega \notin \lambda(\omega)$ for all $\omega \in \Omega$. Thus, no agent can consume the variety of the good that he produces. An agent of type $\omega \in \Omega$ obtains instantaneous utility $u(x|\omega, \omega')$ if he consumes x units of the variety $\omega' \in \lambda(\omega)$ and pays an instantaneous production cost x if he produces x units of the variety ω. We let $u(x|\omega, \omega') = 0$ when $\omega' \notin \lambda(\omega)$ and assume that for each $\omega \in \Omega$ and $\omega' \in \lambda(\omega)$, the function $u(x|\omega, \omega') - x$ has a unique and positive maximizer $x^*(\omega, \omega')$.

Trade occurs in a decentralized market with pairwise meetings. Let Ω_t be the set of types of agents who are alive in period t. For all $t \geq 1$, there exists a map $M_t : \Omega_t \times \Omega_t \to [0, 1]$ such that $M_t(\omega, \omega') = M_t(\omega', \omega)$ is the probability that an agent of type $\omega \in \Omega_t$ is matched with an agent of type $\omega' \in \Omega_t$ in period t. Meetings are random conditional on the types of agents matched. There are no double-coincidence meetings, that is, if $\omega, \omega' \in \Omega$ are such that $\omega' \in \lambda(\omega)$, then $\omega \notin \lambda(\omega')$.[7] The sequence of events in a pairwise meeting is as follows. First, each agent observes the identity and type of his partner and the information that the monitoring technology makes available in the meeting. Then, each agent simultaneously and independently chooses his action, that is, how much to produce to his partner. Finally, consumption occurs.

Let $T(\omega) = \sup\{t \geq 1 : t \in N(\omega)\}$. An agent of type ω is finitely lived if $T(\omega) < \infty$, in which case $T(\omega)$ is his last period in the economy. We make the following assumption:

(A1) $M_{T(\omega)}(\omega, \omega') = 0$ for all $\omega, \omega' \in \Omega$ such that $T(\omega) < \infty$ and $\omega \in \lambda(\omega')$.

Thus, as in an overlapping generations framework, a finitely lived agent cannot be a producer in his last period of life. Now, for each $t \geq 1$ and $\omega, \omega' \in \Omega_t$ such that $\omega \in \lambda(\omega')$, let

$$\Delta_t(\omega, \omega') = -x^*(\omega', \omega) + \sum_{\omega'' \in \lambda(\omega) \cap \Omega_{t+1}} M_{t+1}(\omega, \omega'')u(x^*(\omega, \omega'')|\omega, \omega'').$$

3 Mills (2007) considers the case in which the private histories of a subset of agents in the population are publicly revealed with a lag. Cavalcanti et al. (1999) consider a monitoring technology which publicly reveals a summary of the private histories of a subset of agents. Jin and Temzelides (2004) consider an economy in which agents interact both locally and globally and assume that private histories are publicly observed only at the local level. Gomis-Porqueras and Sanches (2013) consider a variant of the monitoring technology of Cavalcanti et al. (1999) in an environment based on Lagos and Wright (2005).

4 The non-essentiality result in Aliprantis et al. (2007) depends on the assumption that all actions in the centralized market are publicly observed without noise. Araujo et al. (2012) extend the analysis in Aliprantis et al. (2007) to the case in which only prices are observed (possibly with noise) in the centralized market.

5 Rosenthal (1979), Kalai et al. (1988), Bhaskar (1998), and Olszewski (2007) consider similar equilibrium constructions. Awaya (2014) extends Takahashi's analysis to the case in which agents can observe their partner's past play but only at a (small) cost.

6 Our model corresponds to Takahashi's model with $g = l$.

7 It is straightforward to extend our analysis to cover the case in which double-coincidences are possible.