FIAT MONEY AND COORDINATION:

A "PERVERSE" COEXISTENCE OF PRIVATE NOTES AND FIAT MONEY

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INTRODUCTION

Recently there has been renewed interest in coordination problems, and, in particular, in monetary aspects of coordination. This paper attempts to combine important insights developed in the literature on matching models of money (in particular Kiyotaki and Wright [1989], Kocherlakota [1998] and Cavalcanti and Wallace [1999]) with insights from the macroeconomic coordination game-technological complementarity literature (in particular see Cooper [1999] and Cooper and Corbae [2001]). Taken together, these two related literatures may yield further insight into the relationship between production coordination and outside fiat money, and, thereby, into the coexistence of private notes and outside fiat money.

One important old insight, but which has been refined lately (see Kocherlakota [1998]), is that money is imperfect information. Further, one simple specification of incomplete information in particular, which has proven fruitful in motivating outside fiat money in matching environments, is to assume that agents are unidentifiable (see Cavalcanti and Wallace [1999]). This paper adopts this approach. In earlier work, it has also been argued that outside money has a direct role to play in production coordination itself. This is not surprising as imperfect information is also an ingredient in production coordination failure. Indeed, the use of currency may facilitate production coordination. For example, Bryant [2002] argues that (historically observed) indemnification with gold may have facilitated coordination in bills of exchange markets. On the other hand, this paper considers another, and very different, possible aspect of the relationship between outside money and production coordination, in a matching model of incomplete information. Outside fiat money can actually have its very demand induced by the anticipation and realization of a production coordination failure that, in self-fulfilling fashion, its own existence facilitates! Moreover this "perverse" demand for outside fiat money coexists with private notes.

IMPERFECT INFORMATION AND MONEY: PRELIMINARIES

Money involves imperfect information. To exploit this feature, in a dynamic production coordination context, consider a joint production model of two-period lived

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overlapping generations of otherwise *ex ante* identical individuals (agents). There are $2N$ such individuals (N a large number) in each generation. The imperfect information-monetary aspects emerge in a simple matching structure. At the beginning of their first period of life these individuals are endowed with L units of a single good, sometimes hereafter referred to as input. They are paired with another individual of the same generation. Only one of a pair (but either) can be chosen, by the pair, to be fabricator. The fabricator can transform good endowment in this period into good in their second period of life, yielding the amount $x2\min[I_1,I_2]$, $x>1$, where I_1 is input (first period of life good) from the fabricator's initial good endowment, and I_2 is input from the worker's initial good endowment. (This is the archetypal production complementarity presented in, for example, Cooper [1999,viii-xiii, 2-5, 41-46, 60, 148-149] and variously referred to as the "min-rule" the "Stag Hunt," and "Bryant's game.") It is the only way to transform good this period into good next period. In the second period of life individuals are re-paired, the simple matching structure, but a fabricator with a worker. All consumption occurs in the second period of life. Produced good cannot be used as input, but only for consumption (these overlapping generations would not do so anyway). However, good endowment of the next generation can be consumed by this generation as well, as a perfect substitute for produced good. Thus the model does exploit the standard overlapping generations (OLG) consumption-loans structure. Individuals have an identical utility function U, which is smooth, increasing, strictly concave and with strictly convex upper contours (implying $U'(0) = \infty$).

Money is imperfect information. However, in some circumstances of imperfect information, private notes suffice. To illustrate this possibility, limited imperfect information is introduced to the matching structure. In particular, suppose that the workers are unidentifiable in their second period of life. However, the fabricators are identifiable in their second period of life. Hence the fabricators can issue notes in their first period of life, for redemption in the second. This note issuance can be manifested in two ways. If they can communicate with each other in their first period, fabricators can, as implied by symmetry, agree to accept each other's notes, at par, in their second period of life. Alternatively, in their second period of life, mobile workers can simply seek out their identifiable partner from the first period, and present her with her own notes for collection (assuming that the notes, if not the workers themselves, are identifiable). Thus fabricators issue notes, in their first period of life, redeemable for xL goods, to be available in the next period, to the workers, in return for L units of input in their first period. The output of a fabricator in the second period is $2xL$ units of goods, and fabricators and workers each consume xL units of goods in their second period. The fabricators and workers are treated symmetrically. Optimality is obtained, and there is no role for outside fiat money. This is just the standard result in overlapping generations models with productive "storage" (as discussed, for example, by Wallace [1980]). In short, the joint production-backed private notes dominate outside fiat money.

IMPERFECT INFORMATION, COORDINATION AND OUTSIDE FIAT MONEY

The above structure of imperfect information, and of private notes dominating fiat money, does not involve production coordination problems. However, imperfect information can also generate production coordination problems, and a resultant demand

for outside fiat money. That is, if the possibility of production coordination failure is introduced into the environment, then, given the appropriate structure of imperfect information, there is a potential coordination failure-induced demand for outside fiat money, a demand which the private, productive asset-backed notes do not eliminate.

Imperfect information can generate production coordination problems, in the right environment. As described in the model above, individuals meet, choose which is to become fabricator and which worker, and agree to have the worker contribute a certain amount of input to the joint production technology, in return for money (the scale of production is determined at this time). Now suppose that after they do so choose, the paired fabricators and workers must separately, and in isolation, costlessly render their input fit for fabrication by the one chosen to become fabricator. Moreover, and critically for the production coordination problem, suppose that when the input is rendered fit for fabrication, it is also rendered unfit for consumption by the old of the previous generation. However, at this point of isolation, individuals can also just "cut and run." That is, they can take all of their endowment of input to the money market and trade it for outside fiat money with the old, become unidentifiable, and, in the second period of life, trade that outside fiat money for endowment of the next generation, and consume it.

Suppose that one of a pair of individuals, fabricator or worker, were to "cut and run," and sell her input for fiat money, instead of rendering it fit for fabrication. Suppose that the other in the pair does render her input fit for fabrication. The latter now is saddled with input that cannot be used for production, and cannot be sold for money either. Better, then, to have also "cut and run." Of course, it is better yet, for both, if both render their input fit for fabrication as $x>1$: hence the production coordination problem.

This production coordination problem induces the possibility of a demand for outside fiat money, one not satisfied by the private notes, which continue to circulate as well. Indeed, even if in a given generation there is no coordination failure, this generation can still have a demand for outside fiat money, against the possibility that the next generation has coordination failure, and demands outside fiat money.

Stationary sunspot equilibria provide a convenient, and graphic, way to formalize this phenomenon. Indeed, a very simple form of sunspot equilibrium suffices for this purpose. Suppose in each period there is a random variable, the sunspot, taking on either the value "1," "pessimistic," or "2," "optimistic." These random variables are i.i.d. with probability P of taking on the value "1" and $1\text{-}P$ of taking on the value "2." The outcome of the sunspot is seen by everyone at the point when they are, in isolation, deciding whether or not to render their input fit for fabrication. If they see the value "1" they assume that the other in their pair will not render input fit for fabrication, and if they see "2" they anticipate that the other will. Hence "1" implies zero joint production, and everyone "cutting and running," and demanding real balances of outside fiat money equal to their endowment L. "2" implies that the previously determined scale of joint production is produced. In stationary equilibrium there are now four possible values for the gross real rate of return on money, $\pi_{i,j}$, with i being the value of the random variable in "this" period and j being the value of the random variable "next" period, with $i,j=1,2$. Further, $\pi_{11}=\pi_{22}=1$ in stationary equilibrium, with a constant nominal money stock. In equilibrium $\pi_{21}=L/M$, where the real demand for

fiat money by this "optimistic" generation is designated M, and where the real demand by the "pessimistic" next generation, who "cut and run," is L, their endowment. Hence one must indeed allow for the possibility that in the "non-shocked" state "2" money is held against the eventuality that the next generation is "shocked," and the consequent possibility that money is not dominated in rate of return. π_{22} approaches infinity as M approaches zero. The proposition is that with "2" observed there is a demand for outside fiat money.

With the sunspot present, there is a demand for outside fiat money. In particular, the crucial point, as emphasized above, is that individuals agree that if "2" is observed they hold outside fiat money and produce at the level that maximizes expected utility, conditional on the observation of "2," given that the fabricator issues notes dividing the production equally with the worker. As the fabricator and worker are in a symmetric situation, they hold equal amounts of real balances of outside fiat money, M. Their maximization problem is:

$$\max_{0\le M\le L} [PU(x(L-M)+\pi_{21}M)+(1-P)U(x(L-M)+\pi_{22}M)] \tag{1}$$

We are now ready for the central proposition of the paper.

Proposition: If $1>P>0$, there is a stationary valued outside fiat money sunspot equilibrium; and hence, if, in a given generation, there is no coordination failure, that generation has a demand for outside fiat money, against the possibility that the next generation has coordination failure, and demands outside fiat money.

Proof: Ignoring the constraint on M, the f.o.n.c. implied by equation (1) is

$$(\pi_{21}-x)(PU'(x(L-M)+\pi_{21}M)+(1-x)(1-P)U'(x(L-M)+M)=0\,. \tag{2}$$

In equilibrium $\pi_{21}=L/M$. Substituting this into the f.o.n.c., equation (2) yields

$$(L/M-x)PU'(x(L-M)+L)+(1-x)(1-P)U'(x(L-M)+M)=0\,. \tag{3}$$

As $M\downarrow 0$ the L.H.S. of (3) $\uparrow\infty$. As $M\uparrow L$ the L.H.S. of (3) $\to (1-x)PU(L)$ + $(1-x)(1-P)U'(L) = (1-x)U'(L) < 0$ for $x > 1$. By the continuity of U', $\exists\,\tilde{M}\in(0,L)$ satisfying (3). Therefore $\pi_{11}=\pi_{22}=1$, $\pi_{21}=1/\pi_{12}=L/\tilde{M}$ is a stationary valued money sunspot equilibrium. Q.E.D.

Hence outside fiat money both admits the possibility of a production coordination problem and a resulting, self-fulfilling, production coordination failure-induced demand for fiat money! In such an equilibrium outside fiat money and private notes

coexist, as here outside valued fiat money simply cannot be dominated in rate of return. It is worth further noting that as $\pi_{12} = \tilde{M} / L < 1 < L / \tilde{M} = \pi_{21}$ prices are procyclical in this equilibrium.

SUMMARY

With imperfect information there can be a production coordination problem, which induces its own "perverse" demand for fiat money. Moreover, in such an equilibrium ("productive") production-backed private notes and fiat money can coexist.

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