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5 FINANCIAL STRUCTURES AS COMMUNICATION SYSTEMS

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What determines the financial structure of an economy? How is financial structure related to economic organization generally? In particular, what determines the use or absence of currency? Why are certain closed societies moneyless, such as the early medieval manor, apparently, in contrast say to contemporary industrial economies? And how should we interpret the apparent use of multiple noninterchangeable commodity moneys in some of the primitive societies studied by anthropologists? That is, why does currency seem to be critical to some arrangements but not to others, and what are the defining features of currency that allow us to say that it is or is not in use?

Further, what determines the various forms of private debt? In the reemergence of trade in the commercial revolution of Europe, for example, why does one see, apparently, first simple bilateral debt, then quadrilateral debt in the form of bills of exchange among trading partners, and finally circulating IOUs? What is it that makes these forms of debt different from one another? Related is a series of policy issues. Should high-velocity circulating private debt, such as bank notes in the United States, coexist with centrally issued currency? Is

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there an obvious target for some monetary aggregate? Indeed, what rules ought to govern the amount of outside currency and inside debt in a given society?

Finally, what determines the existence or absence of banks or intermediaries? That is, under what conditions do banks and intermediaries emerge, as in the commercial revolution in Europe? Why does one struggle to see obvious forms of banking in some of the primitive societies studied by anthropologists? More basic, how would we recognize a bank or intermediary, either in a model or in practice? Related again is a series of policy issues. What are optimal banking arrangements? Under what circumstances should a bank be allowed to fail? Should bank contracts be controlled? How much interbank insurance is optimal? Is there a role for a lender of last resort?

Involving observations on social structure and key issues in monetary or regulatory policy, these questions fall naturally and directly into the sphere of economic science. Yet, paradoxically, economists who theorize with general equilibrium models regard these questions as difficult. Simply put, it is hard for a general equilibrium theorist to explain objects and institutions such as currency, various forms of private debt, and banks as the natural outcome of maximizing, interactive agents. The harsh, confining discipline of general equilibrium theory makes it difficult to find an underlying rationale for such objects and institutions. Indeed, these objects and institutions are difficult to define precisely.

One purpose of this chapter is to elaborate on this difficulty facing general equilibrium theorists. That is, one purpose is to describe a view of the discipline of economic science and why it is difficult to get currency and banks into a general equilibrium model and to distinguish in a general equilibrium model the various possible forms of private debt. But a second purpose of this chapter is to identify a key element missing from general equilibrium models, namely, limited communication. That is, a variety of objects and institutions can emerge in a general equilibrium model if there is imagined to be less-than-perfect communication, whereas, otherwise, with full communication, these objects and institutions have no role. In particular, with limited communication, oral assignment systems can emerge, and these seem to capture at least one of the roles of banks, of the type that emerged apparently in Europe during the commercial revolution, for example; portable concealable object systems can emerge

and these seem to capture one of the roles of currency and help to explain (potentially) the noninterchangeable commodity money systems used in certain primitive societies, for example; and written message systems can emerge and these seem to capture one of the roles of written financial instruments, of European bills of exchange, for example. Further, general equilibrium models with limited communication can be specified in such a way that it is possible to deliver qualitative conclusions on optimal monetary and regulatory policy.

THE DISCIPLINE OF GENERAL EQUILIBRIUM THEORY

The view of economic science adopted here is essentially that exposited by Lucas (1980), that a model is an experimental laboratory. We the modelers, or the experimentors, specify the endowments of agents, their preferences, the technology of production and communication available to them, and the information available to them, so that the agents of the model are the subjects of the experiment. We then attempt to predict how the agents will behave. A fundamental tenet for single-agent models is that the single agent will attempt to do as well as possible for himself under the specified endowments, preferences, technology, and information structure, much like Robinson Crusoe. Multiagent models, as Lucas notes, are more complicated, requiring in addition some specified form of interaction of the agents or some premise as to the outcome of that interaction. For example, we might suppose with Lucas that the outcome necessarily be the one that would be achieved in competitive markets, or alternatively that the outcome be in the core, or more weakly that the outcome be Pareto optimal. But the point is that any such premise delivers in principle a mapping from endowments, preferences, technology, and information structure into objects and institutions or at least into final allocations. It is thus that a theory can have empirical content. But this discipline is fairly demanding; it is often difficult to find an environment that delivers the desired observations.

Of course in the end, in any multiagent theoretical model, one must take a stand on the supposed outcome of the interactive process. Supposing that the theoretical outcome is necessarily in the core, it is perhaps the most appealing hypothesis, and of course core outcomes are sometimes coincident with competitive outcomes. Still, it is sometimes difficult to deliver core outcomes as solutions to maximization problems, and it is sometimes difficult to compute competitive equilibrium outcomes directly. Thus this chapter focuses primarily, but not exclusively, on Pareto optimal outcomes, as the weakest but most tractable alternative. That is, to predict an outcome for the environment of a given general equilibrium model one considers the programming problem of maximizing a weighted average of the utilities of the economic agents subject to the constraints implied by the technology and the information structure; the solutions to such programs generally are the Pareto optimal allocations.

UNCERTAINTY AND A STANDARD GENERAL EQUILIBRIUM MODEL

To illustrate in a specific fashion this discipline of general equilibrium theory and the difficulty of explaining financial structure it is useful to begin with a stylized pure exchange economy subject to uncertainty. Suppose there are a finite number of households, indexed by j, $j = 1, 2, \ldots n$ and a finite number of dates, indexed by t, $t = 0, 1, \ldots, T$. Each household j has a strictly concave date t utility function $U^j(c_t^j)$, over nonnegative units of consumption c_t^j of the single underlying consumption good of the model, and each discounts future consumption by (the same) rate β, $0 < \beta < 1$. The endowment $e_t^j(\epsilon_t)$ of each household j at date t of the single consumption good is a random variable, depending on the realization of some publicly observed shock ϵ_t at date t. In fact, these shocks are imagined to follow a first-order stochastic process, with the probabilities of ϵ_t given ϵ_{t-1}, denoted Prob $(\epsilon_t : \epsilon_{t-1})$, as givens. There is presumed to be no storage of any kind.

Following the indexation insight of Arrow (1953) and Debreu (1959), the natural commodity space in this model is the space of shock-contingent consumptions. That is, let $c_t^j(\epsilon_0, \epsilon_1, \ldots, \epsilon_t)$ denote the proposed consumption of agent j at date t as a function of the entire history of shocks, $(\epsilon_0, \epsilon_1, \ldots, \epsilon_t)$. Then we are led to a concave programming problem for the determination of Pareto optimal allocations,

Program 1: Maximize by choice of the $c_t^j(\epsilon_0, \epsilon_1, \ldots, \epsilon_t)$ the objective function

$$\sum_{j=1}^{n} \lambda^j \left\{ E_0 \sum_{t=0}^{T} \beta^t U^j \left[c_t^j(\epsilon_0, \epsilon_1, \ldots, \epsilon_t) \right] \right\} \tag{5-1}$$

subject to the resource constraint

$$\sum_{j=1}^{n} c_t^j(\epsilon_0, \epsilon_1, \ldots, \epsilon_t) \le \sum_{j=1}^{n} e_t^j(\epsilon_t) \ . \tag{5-2}$$

Here then we are maximizing a weighted average of the utilities of the households where for simplicity the weights satisfy

$$0 < \lambda^j < 1, \quad \sum_{j=1}^{n} \lambda^j = 1 \ . \tag{5-3}$$

Expectations for all households are taken as of the initial date, $t = 0$, conditioned on the beginning of period shock at $t = 0$, namely ϵ_0. Thus $t = 0$ is denoted a planning period. Note also that these and any other expectations are held in common. Finally, (5-2) is the obvious resource constraint, bounding the sum of consumptions.

Supposing interior consumption solutions for all households at all dates and histories leads to first-order conditions

$$\begin{aligned} &\beta^t \lambda^j \text{Prob}\,(\epsilon_1, \epsilon_2, \ldots, \epsilon_t : \epsilon_0)\, U^{j\prime} \left[c_t^j(\epsilon_0, \epsilon_1, \ldots, \epsilon_t) \right] \\ &= \mu(\epsilon_0, \epsilon_1, \ldots, \epsilon_t), \qquad j = 1, 2, \ldots, n \end{aligned} \tag{5-4}$$

where $\mu(\epsilon_0, \epsilon_1, \ldots, \epsilon_t)$ is the Lagrange multiplier on the resource constraint at date t and history $(\epsilon_0, \epsilon_1, \ldots, \epsilon_t)$. Thus the aggregate endowment is to be distributed so that weighted marginal utilities are equated across all households. And thus it becomes apparent, with a common discount rate and common expectations, that only the magnitude of the aggregate endowment

$$\sum_{j=1}^{n} e_t^j(\epsilon_t) \equiv e(\epsilon_t) \ ,$$

matters in the determination of *any* household's consumption, not the date nor the history. That is, with some abuse of notation, each c^j depends only on the aggregate endowment e. Further, the residual, "static," one-period risk-allocation problem has been studied by Wilson (1968), yielding in the continuous random variable case

$$\frac{\delta c^j(e)}{\delta e} = \frac{-U^{j'}\left[c^j(e)\right] / U^{j''}\left[c^j(e)\right]}{\sum_k \left\{-U^{k'}\left[c^k(e)\right] / U^{k''}\left[c^k(e)\right]\right\}} \qquad (5\text{-}5)$$

so that

$$0 \leq \frac{\delta c^j(e)}{\delta e} \leq 1 \qquad (5\text{-}6)$$

for every household j. In short, each household's consumption must vary positively (weakly) with the aggregate endowment, both over shock realizations at a point in time and over time.

As I have argued elsewhere, in Townsend (1985), these strong implications are robust to the inclusion of storage, leisure, nontrivial production, and a variety of consumption goods, at least under certain specifications of utility functions. And thus we might check to see whether these implications hold in an actual economy. But it is a striking implication of the theory that nothing resembling currency, financial instruments, or banks are needed to support an optimal arrangement. Agents need only agree on the optimal resource allocation rule, and none of these objects or institutions are critical to effecting any such agreement. One must conclude then that something is missing from the theory.

THE INTRODUCTION OF IMPEDIMENTS TO TRADE—SPATIAL SEPARATION AND PRIVATE INFORMATION

One way to try to remedy these deficiencies is to incorporate into the general equilibrium model some impediments to trade. An obvious possibility that suggests itself from theoretical considerations is an absence of double coincidence of wants, that is, when neither of two agents has something the other agent wants. As suggested in Townsend and Wallace (1984), this absence of double coincidence implies some separation of agents in space. Further, observations on the use or absence of currency and banks in actual economies also suggests explicit treatment of spatial separation.

Thus consider an economy with two locations, two dates, and four agents, as described in Table 5-1. Here agents a and a' reside in loca-

Table 5-1. Agent Pairings in a Spatial Economy.

	Location 1	Location 2
$t = 1$	(a, b)	(a', b')
$t = 2$	(a, b')	(a', b)

tions 1 and 2 respectively, for both dates, while agents b and b', for unspecified exogenous reasons, switch locations at the beginning of the second date. Agents are imagined to have endowments and preferences over consumption goods in each location where they happen to be.

One could write down a concave programming problem for the determination of a Pareto optimum for this spatial economy, much like Program 1, except that here there would be a resource constraint not only at each date and history but also at each location. Thus one would distribute the consumption good at each particular location among all participants at each particular location in such a way as to equate weighted marginal utilities. In short, individual consumptions would vary positively (weakly) with location-specific aggregates at a point in time over shock realizations, and to the extent that a population remained unaltered, over subsets of dates at any location, individual consumptions would vary positively (weakly) with location-specific aggregates over time. But the distribution of the consumption good would be sensitive, generally, to the population mix at any given location, making the implications of the theory more difficult but not impossible to test. (Of course conclusions like this would hold even if entire groups of a given population were to move about exogenously.)

A more elaborate treatment of spatial separation, required in a serious application, would recognize that location choices can be endogenous and that individuals are capable of consuming leisure and supplying labor in any location they might choose. This raises a potential nonconvexity problem, but fortunately the problem can be solved by going to a space of lotteries. That is, one can still determine Pareto optimal arrangements by finding solutions to concave programming problems, as I have argued elsewhere, in Townsend (1985a). And these programs, of Gary Hansen (1985) and Richard Rogerson (1984) for example, offer a rich variety of time series dynamics, potentially explaining observed volatilities and persistence. Yet, despite the spatial separations and this rich variety of time series dynamics, nothing in the theory argues that an optimal arrangement has to be decentralized in order to be effected. Thus, there is still no essential role in the theory for currency, financial instruments, or banks.

A second way to try to remedy this deficiency is to incorporate private information. The idea is that private information somehow might provide the decentralization necessary for familiar objects and institutions to emerge.

Thus consider an essentially static, pure exchange economy with two agents, a and b, each endowed with an n-dimensional vector of consumption goods dependent on some shock ϵ. In fact, suppose realizations of the endowment of agent a, $e^a(\epsilon)$, are seen by agent a alone, say taking on at most two values, θ' and θ'', with generic element θ. And suppose for simplicity realizations of the endowment of agent b, $e^b(\epsilon)$, are public, say some constant W. Were we to solve programming problem (5-1) for this special case, ignoring the private information, we would deduce the fact (with risk aversion) that consumptions of agents a and b should be functions of the aggregate endowment, $W+\theta$, or, for simplicity, just θ, and we could write $c^a(\theta)$ and $c^b(\theta)$.

But now a potential problem emerges. For let $f^a(\theta)$ denote the effective *net* transfer that agent a is to receive when his endowment is θ, that is, $f^a(\theta) \equiv c^a(\theta) - \theta$. It is possible that

$$U^a[\theta' + f^a(\theta')] < U^a[\theta' + f^a(\theta'')] \quad , \tag{5-7}$$

so that if the endowment of agent a were actually θ' and he were asked to name a value for it, he would choose to name θ'', and the allocation to him would be $\theta'' + f^a(\theta'')$ rather than $\theta' + f^a(\theta')$.

As is apparent, this problem might be remedied by the imposition of (5-7) with the inequality reversed, that is,

$$U^a[\theta' + f^a(\theta')] \geq U^a[\theta' + f^a(\theta'')] \tag{5-8}$$

$$U^a[\theta'' + f^a(\theta'')] \geq U^a[\theta'' + f^a(\theta')] \quad . \tag{5-9}$$

That is, one might be tempted to impose constraints (5-8) and (5-9) directly onto programming problem (5-1) before deriving a solution. In fact, it is the implication of the work of Myerson (1979) and of Harris and Townsend (1981) that such a procedure can be rigorously

justified. In economies with private information there is essentially no loss of generality in imposing such incentive compatibility constraints; such constraints capture all the additional restrictions associated with private information.

One qualification to this discussion should be noted, however: When there is private information on quantitites, as in the economy just described, constraints like (5-8) and (5-9) sometimes can be weakened. In effect, agent a could be asked both to name a value for his endowment *and* to display the endowment if necessary, as evidence of his claim. Formally, this can be captured by allowing agent a to transfer some amount of his consumption good to some center, as a "tax," before receiving any compensation, as a "subsidy."

More formally, then, let $T(\theta)$ denote the set of all feasible displays or "taxes" $\tau = (\tau^a, \tau^b)$ on agents a and b, respectively, satisfying constraints $0 \leq \tau^a \leq \theta$ and $0 \leq \tau^b \leq W$. Similarly, let $S(\tau)$ denote the set of all second-round, conditional "subsidies" $s = (s^a, s^b)$ on agents a and b, respectively, satisfying the constraints $s^a \geq 0, s^b \geq 0$ and $s^a + s^b \leq \tau^a + \tau^b$, so that the sum of subsidies is bounded by the sum of the taxes or "displays." Next, let $\pi^\tau(\theta)$ be a lottery on the space $T(\theta)$, and let $\pi^s(\theta, \tau)$ be a conditional lottery on the space $S(\tau)$. Agent a is then imagined to choose lotteries $\pi^\tau(\theta)$ and $\pi^s(\tau, \theta)$ conditioned on his announcement of θ. The programming problem (5-1) is thus reduced to

Program 2: Maximize by choice of the $\pi^\tau(\theta)$, $\pi^s(\theta, \tau)$ the objective function

$$\begin{aligned} &\lambda^a \left\{E_\theta \textstyle\int\int U^a[\theta - \tau^a + s^a]\, \pi^\tau(d\tau, \theta)\pi^s(ds, \theta, \tau)\right\} \\ &+ \lambda^b \left\{E_\theta \textstyle\int\int U^b[W - \tau^b + s^b]\, \pi^\tau(d\tau, \theta)\pi^s(ds, \theta, \tau)\right\} \end{aligned} \tag{5-10}$$

and given endowment $\theta = \theta'$ subject to either

$$\pi^\tau(\theta'') \text{ is } \textit{not} \text{ a lottery on the space } T(\theta') \quad , \tag{5-11}$$

so that some realization of the tax lottery or display is not feasible given $\theta = \theta'$, or

$$\begin{aligned} &\textstyle\int\int U^a[\theta' - \tau^a + s^a]\, \pi^\tau(d\tau, \theta')\pi^s(ds, \tau, \theta') \\ &\geq \textstyle\int\int U^a[\theta' - \tau^a + s^a]\, \pi^\tau(d\tau, \theta'')\pi^s(ds, \tau, \theta'')] \quad , \end{aligned} \tag{5-12}$$

so that agent a has no incentive to lie, announcing θ'' given the endowment is $\theta = \theta'$, and subject to

$$\text{similar constraints when the endowment is } \theta = \theta'' . \qquad (5\text{-}13)$$

Techniques like this turn out to be surprisingly robust, that is, able to handle a wide range of private information problems. First, of course, one can handle situations with private information on actions, as in the standard principal-agent problem (see Myerson 1982). Second, one can also handle situations in which private information can be made public at some cost, as with (potentially random) audits or monitoring technologies, triggered by announcements of agents with private information (see Townsend 1979 and Baiman and Demski 1980). Third, one can handle multiperiod problems, even with period-by-period private information, as in Townsend (1982). And finally, one can handle multilateral private information even in multiperiod contexts.

The imposition of incentive compatibility constraints onto otherwise standard programming problems can make considerable difference in solutions. That is, private information Pareto optima often differ radically from full information Pareto optima. One can deliver with private information share-cropping arrangements, quid pro quo labor inducements, and intertemporal tie-ins of the type observed at least qualitatively in actual communities. Further, it seems from the work of Prescott and Townsend (1984) and Ito (1984) that one can deliver volatility and also persistence, as I have argued elsewhere, in Townsend (1985a). But the attempt at decentralization has been less successful. The theories as they stand have no essential role for markets and do not seem to deliver currency, various forms of private debt, or a necessary role for intermediaries.

ONE WAY OUT OF THE DILEMMA—LIMITED COMMITMENT

What the theory is missing, apparently, is some lack of commitment. That is, in the programming problems described above it is as if agents agree at some initial date to allocation rules for future dates, contingencies, and locations—rules that are costlessly enforced and maintained despite possible time inconsistencies and incentives to renege. In fact, it may be difficult to enforce such rules and prevent reneging, and this can be an important determinant of actual arrangements.

A natural way to modify the theory is to suppose that planning problems must be solved successively, period-by-period, perhaps for particular and potentially variable weights λ^j across agent types j. Thus there would be no precommitment to a social rule, and agents would do what is best for themselves at the moment, looking forward to the future. Indeed, this leads logically to the notion of a "sequential core." In some last period, if there is one, the allocation of consumption goods must be in the core, not blocked by a coalition of agents. With the prespecified direct utility functions for consumption, this core outcome then induces indirect utility functions or value functions for all agents, perhaps up to the obvious state variables such as beginning-of-period capital holdings (or currency). Then, in the next-to-last period, the allocation of consumption goods and capital (currency) must be in the core, given the current state and given the contemporaneous direct utility functions and the above-derived next period value functions. Continuing in this way, perhaps indefinitely so as to be rid of sensitivity to initial conditions, one can generate stationary sequential core outcomes.

An equivalence between core allocations and competitive equilibrium allocations helps to make the connection to models with valued currency and sequential competitive markets. In the models of currency with spatially separated agents described in Townsend (1980), for example, agents move about exogenously from location to location, trade commodities against paper currency in competitive markets when they meet, and then continue on, perhaps never to meet again. Thus what is termed a noninterventionist, monetary equilibrium in Townsend (1980), one with valued currency, turns out to be essentially equivalent with a sequential core outcome described above, and the role played by currency when commitment is limited is thereby explained.

The spatial models of currency of Townsend (1980) are also consistent in some gross sense with observations on the emergence of circulating currency in the commercial revolution of Europe and the coincidence of that emergence with market exchange. But these models have a start-up problem: They fail to explain how currency gets into the system in the first place. That is, the coordination and commitment among agents needed to solve this start-up problem seem to wipe out currency altogether. Related, these spatial models are not well suited for normative or policy analysis; only the laissez faire equilibria are appropriate to examine. And finally, we are left wondering if there might yet be some role for currency in close-knit groups or communities where the absence of precommitment is not a problem.

A SECOND WAY OUT OF THE DILEMMA—LIMITED COMMUNICATION

We now note the fact that despite the incorporation of spatial separation and private information, all the economies considered, with the exception of those of the last section, have centralized costless record-keeping devices. At each transaction or meeting agents report on privately observed shocks and receive transfers contingent on the contemporary reports in all locations and contingent on the entire history of past reports in all locations. Thus it is as if there were a perfect costless electronic economywide accounting system. This suggests a consideration of more limited communication-accounting systems in an effort to explain observed forms of economic organization.

To begin the discussion, then, it is useful to merge the private information economy generating Program 2 with the spatial model depicted in Table 5-1. In particular, agents a and a' have the location patterns displayed in Table 5-1 and have random, privately observed endowments θ^{a}_{1t} and $\theta^{a'}_{2t}$, observed at the beginning of date t, $t = 1, 2$, at locations 1 and 2, respectively. Agents b and b' move according to the specified pattern of Table 5-1 and have public endowments W^{b}_{it} and $W^{b'}_{it}$ at location i and date t. Each agent j has preferences over consumption bundles c at each date t at his assigned location i as represented by the utility function $U^{j}(c^{j}_{it})$. Also, for simplicity, suppose there is only one underlying consumption good, that agents a and a' are identical in preferences and in the distribution of endowments, that agents b and b' are identical as well, and that agents b and b' are risk neutral.

Now suppose that the most primitive of communication technologies is in effect, that is, that there are no electronic telecommunications, no recording devices, no portable but otherwise worthless tokens, and no storage possibilities for bona fide commodities. At each location and date agents *can* make announcements of their contemporaneous but privately observed endowments and can make

Table 5-2. Intertemporal Itineries with Three Agents.

Location	*1*	*2*
Date 1	(a, b)	(c)
2	(a, c)	(a)
3	(a, b, c)	Φ

announcements as well of their histories of privately observed endowments, trades, and announcements. Thus one can consider allocation rules $\pi^{\tau}_{it}(\cdot)$ and $\pi^{s}_{it}(\cdot)$ at location i and date t which have as arguments these announcements, and it is possible to write down a programming problem for the determination of Pareto optimal outcomes, much like Program 2, keeping track of the four agents and two locations. However, in *any* incentive compatible arrangement, announcements of past histories have no force. That is, *given the imposed communication technology*, there is no way to achieve bona fide intertemporal tie-ins, as agents will always make the best possible announcements given the contemporaneous state. Thus the programming problem would reduce to four separate versions of programming problem (5-7). With only one commodity, then, the solution is necessarily autarkic, at least if utility functions of agents a and a' display decreasing absolute risk aversion (see Townsend 1985a).

This dismal outcome can be avoided if the spatial itinerary of agents is altered or if the communication technology is slightly improved. Taking the first suggestion, suppose agents b and b' do not move in the above model. Then, as in Townsend (1982), intertemporal links and beneficial trade are possible. Indeed, more elaborate setups in which agents return periodically to some go-between allow beneficial trade and suggest a model of an intermediary. Imagine, for example, the pattern of pairings displayed in Table 5-2. Here agent a can report to agent b, on shocks θ^{a}_{1} at the first date, and agent b can report on the announcements to agent c at the second date. The third date provides intertemporal tie-ins which give these reports some force. Here then, agent b serves as an intermediary.

Taking the second suggestion above, while still precluding electronic telecommunications and commodity storage, suppose the existence of portable concealable artificial tokens, objects that do not enter into anyone's utility function or into any production technology but which can be carried by the agents and redistributed from one to another at any location where they meet, say under the prespecified rules of a resource allocation process. Then in the model considered above beginning of second-period token holdings become in effect an endogenously determined, privately observed endowment, an extra state variable which can be announced by the agents, triggering taxes (displays) and subsidies of both tokens and actual commodities. Indeed, with the symmetry and neutrality assumptions, one can then write down as (apparent) two-agent, two-period programming problem, much like programming problem (5–7) essentially, except that there are token as well as commodity taxes and subsidies at the first date, contingent on a (or $a''s$) endowment at the first date, say θ_1; that there are token as well as commodity taxes and subsidies at the second date, contingent on a (or $a''s$) endowment at the second date, say θ_2, *and* on a's beginning of second-period token holdings, say m_2; and that there are incentive constraints in both the first and second periods, to ensure truthful revelations. As promised, it can be shown that these portable concealable tokens allow beneficial multilateral trade, rather than autarky as above.

In Townsend (1985b) these results are extended in several directions. The first is to consider alternative communication technologies. For example, if one considers storage and bona fide commodity tokens, intertemporal incentive constraints generally are more binding and the solutions to programming problems generally are Pareto inferior; essentially, commodity storage confounds the use of objects as signals of past events. Alternatively, systems with multiple tokens can be shown to dominate single-token systems; that is, multiple tokens allow more intertemporal tie-ins and hence weakened or less binding incentive constraints. Written message systems do even better, generally, in the sense that more history becomes a matter of reliable record and not subject to the requirements of incentive compatible reporting. And centralized electronic interspatial telecommunication systems represent an endpoint in the spectrum of communication technologies, essentially removing limited communication as a constraint on the outcomes of programming problems.

These private information, spatial separation, limited communication setups can be taken to observations from actual economies. For example, the role for intermediaries described above may help us to understand the role played by medieval bankers, in the twelfth century in Italy, for example, as described in Townsend (1984). There, bankers were part of person-specific oral assignment systems. Similarly, as is argued in Townsend (1985b), observations by anthropologists on the apparent use of noninterchangeable commodity currencies and ceremonial objects in various close-knit primitive societies are not wildly inconsistent with the use made in the theory of multiple portable tokens. There is also some evidence that written financial instruments emerged in Europe in the fifteenth century as written messages sent among partners in long-term trading relationships, somewhat like the written messages of the theory.

Another direction for this work is the study of optimal monetary policy, as in Townsend (1985c). For example, in writing down a programming problem for the determination of optimal arrangements in the setup described above, one is naturally poised to ask questions concerning the optimal social use of tokens in the face of various private and economywide shocks. One can use as a base the model of Diamond and Dybvig (1983), in which groups of agents suffer from privately observed shocks determining their urgency to consume: The more urgent is consumption the more goods an agent withdraws from an otherwise productive investment project. On this base, then, one can impose some spatial separation, say two spatially separated investment projects, and suppose that groups of agents are exogenously shifted over time, much like single agents b and b' above. In this context, tokens can serve as concealable records of deferred consumption for patient movers, and it can be shown that both the level of tokens and the mix of tokens to location-specific "bank credits" should be responsive to the economywide shocks determining the relative number of lenders and relative number of movers. Thus the limited communication rationale for currency delivers an optimal activist currency rule.

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COMMENTARY ON CHAPTER 5

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These are interesting times in monetary economy. There is general agreement that the old approach as reflected in asset demand systems is inadequate and if we are to make progress a new approach is needed. The two prominent alternatives are Wallace's overlapping generations model with legal constraints and Lucas's and Stokey's cash-credit good dichotomy. Neither of these approaches nor the asset demand system, which preceded them, seems adequate for evaluating alternative credit and payment systems.

With Townsend's mechanism approach to monetary economics, however, the fundamental issue of what arrangement should be adopted, given the communication technology, can be addressed. Moreover, there is some hope of determining the potential gains, if any, that can be realized by adopting a suitable collective arrangement. Given the importance of the question of whether collective monetary and credit arrangements are needed for efficient outcomes, the Townsend line of inquiry warrants serious consideration.

Before proceeding with these comments on the mechanism approach to monetary theory, I shall briefly review why the asset demand approach has largely been abandoned. It can and has been criticized because assets have been introduced as arguments of the utility function. This is a legitimate criticism of attempts to implement the approach, but is it a fair criticism of the approach itself? Assets are a durable good that do not depreciate. The differences between