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9 Theories of Contract Design and Market Organization: Conceptual Bases for Understanding Futures Markets

Robert M. Townsend

Why are there organized futures markets? Do such markets constitute an optimal social arrangement? Should society encourage the development of such markets or control their operation? Of course, this chapter does not pretend to offer a definitive answer to these questions. But it does argue that a number of relatively recent efforts in the theory of general economic equilibrium can help us to explain the existence of organized futures markets and help us to pose and to answer normative questions. The purpose of this chapter, then, is to review those efforts and advance some new frameworks—all with the hope of furthering subsequent research efforts.

To motivate the general equilibrium models presented here, it is useful to review first the standard Arrow-Debreu general equilibrium model and to comment on its ability to explain the existence of organized futures markets. Two polar and somewhat characterized views are presented that motivate the intermediate view adopted in this paper. Next, I review the present case for the regulation of futures markets, as presented by James M. Stone, former chairman and current commissioner of the Commodity Futures Trading Commission. Again, Stone's views serve to pose more sharply some of the normative (policy) issues. These discussions are followed by the models themselves and some concluding remarks.

Do We Live in an Arrow-Debreu World?

Imagine an economy with a finite number of firms. These firms have well-behaved technologies for transforming a finite number of factors of production into a finite number of produced goods. Production takes place both at a point in time (for example, labor is used to manufacture consumption goods) and over time (for example, labor is used to manufacture consumption goods) and over time (for example, there are nontrivial investment capabilities). Finally, firms' production technologies are subject

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to random disturbances or shocks (for example, good or bad weather affects crop yields). The firms of the economy are owned by households. The households themselves are endowed with factors of production and have well-behaved preferences over such factors not supplied (such as leisure) and over consumption of produced goods. Again, endowments and preferences may be random.

Now imagine that at the beginning of time all firms and households get together to plan what to do. Under one possible planning scheme, a neutral auctioneer calls out prices specifying per unit credits and debits for sales and purchases in terms of some abstract unit of account or numeraire. That is, firms make commitments (that is, they enter into contracts) to hire inputs and to produce consumption goods contingent on various possible events (such as the entire histories of the technology, endowment, and preference shocks). Firms maximize profits, the valuation of their plan under the accounting system. Households make commitments to sell factors of production and to purchase consumption goods under various possible events or contingencies, subject to the budget constraint that the valuation of their purchases not exceed the valuation of their sales. The auctioneer finds prices of factors of production and consumption goods such that all plans are consistent. Then, as time evolves and states of nature are realized, all contracts are honored.

Under a second planning scheme, there are various possible auctioneers who compete with one another. In fact, one may imagine that any households that want to can offer to buy and sell commodities at specified prices. One can conjecture that the outcome of the second scheme will be the same as the outcome under the first scheme, at least if the number of households and firms is large.[1]

Finally, we might weaken the requirement that everyone meet together at an initial planning date, as if everyone were in the same physical location. Instead, imagine that there is a perfect telecommunications system at the initial date and all households and firms are armed with costless and unlimited computers. Still, households and firms are imagined to make commitments to brokers who compete with one another. The outcome should again be the same.

Of course, the economy just described is the Arrow-Debreu general equilibrium model, or at least a contemporary version. Perhaps some would argue that the Arrow-Debreu model is irrelevant, that it has no relationship to actual markets and institutions. On the other hand, others might argue that the Arrow-Debreu world is essentially the world in which we live. It is true that transactions are entered into over time, but the outcome is equivalent with the outcome of the world with complete Arrow-Debreu markets as just described. Frictions, it is argued, are unimportant; money (checking accounts) is not needed in a world with free access to mutual funds, for

example. The only challenge, according to this second view, is to determine the appropriate sequence of trades and combination of financial instruments, trades, and combinations that allow one to attain the Arrow-Debreu competitive equilibrium allocation.

Naturally enough, the paper adopts a third view. The Arrow-Debreu model is not so wild, despite the apparent absence of observed institutions and markets. After all, we do want highly stylized models; the Arrow-Debreu model is a useful starting point. But the Arrow-Debreu model is missing important frictions or obstacles to trade, obstacles that are not so easily circumvented. The idea, then, is to try to model those frictions and to let observed contracts and institutions emerge endogenously. In this way one might hope to explain futures markets. And in proceeding in this way, keeping track of preferences, endowments, and technologies, one might hope to do explicit welfare analyses. That is, such frameworks provide natural structures in which to pose organization and regulatory issues. This chapter, then, tries both to help us to understand the properties and limitations of the standard Arrow-Debreu model and to review a number of recent efforts in the theory of general economic equilibrium that introduce explicit trading frictions.

Should Society Control the Operation of Futures Market?

To pose the normative and policy issues more sharply, it will prove useful to review the case for regulation of futures markets as presented by Stone (1981). First, Stone proposes that

> Government regulation has commonly been brought to bear in situations where one person is entrusted with other people's money. The trust characteristic of the futures trade and consequent opportunities for customer loss though insolvency and illicit conversion of funds contribute to the first leg of what I will call the tripod of reasons to regulate. . . . As in banking, insurance, and elsewhere, the public authorities feel a need to minimize this risk. . . (by) maintenance of special segregation accounts for customer funds as well as minimum capital requirements. Reinforcing the first leg of the tripod is the extreme difficulty of the customer in assessing the value of the futures contract and the quality of service rendered. . . . [T]he natural intricacy of price determination in any contingent goods market leads further to the customers' problem. Finally, it is difficult to distinguish even in retrospect between the effect of incompetent or unscrupulous activities on the part of a broker or trader and the impacts of accepted market contingencies. Government encourages good faith (of the retailer) . . . by providing disclosure rules, punishing deceit, and providing a civil forum.

Stone then goes on to say:

> The second leg of the regulatory tripod is the potential for abuses of concentration by large position holders in the futures marketplace. From the inception of futures markets it has been well understood that contingent asset markets with quantities sold not limited to expected physical supply are vulnerable to squeezes and other abuses of market power. . . . The threat that some individual or group will hold a position surpassing deliverable supply is a danger constantly overhanging the futures markets. . . . The exchanges themselves provide a first line of defense against congestion and manipulation. Their historical performance, however, is uneven. When key exchange members themselves or their most valued customers are the large position holders, the record of self-regulation is inadequate. . . . Regulatory review . . . of proposed contract specification and trading rules is useful . . . . Speculative position limits help provide a constraint on excessive market size and market power. The Commission's large trader reporting requirements allow constant monitoring.

And, third, Stone remarks:

> The third leg of the tripod is the inclination toward monopoly or oligopoly on the part of exchanges and clearing organizations. . . . That tendency can be traced to powerful scale economies in operating technology, liquidity, and product acceptance, as well as from quasigovernmental rulemaking powers with which an exchange is imbued. . . . Government recognizes the reality of natural monopolistic inclinations by its grant of a franchise to contract markets.

Stone has much to say about approval of new contract applications:

> statute and regulation provide for an economic purpose test, a burden of proof upon the exchange that its proposed contract will be of some demonstrable value to commerce. . . . Futures contracts with no economic or commercial purpose look suspiciously like (gambling) arrangements. . . . Commercial purpose is served when a futures market will do a more effective price job than the preexisting cash markets. . . . Efficiency depends largely upon the knowledge and behavior of participants in a marketplace . . . hedging and price discovery . . . are for the most part corollaries of (the commercial purpose) test . . . . It is relatively easy to make a case for commercial value in the grain futures markets. . . . The atomized nature of cash grain markets and the diversity in those markets with respect to quality rendered elusive the development of an efficient central cash market in most grains. . . . A contrasting and more difficult case for commercial value analysis arises in the financial futures markets.

Stone concludes his essay by noting the paucity of an economic literature on futures market regulation.[2] But Stone's arguments and observations allow one to draw some links to some efforts in the theory of general

economic equilibrium.[3] Again, the idea is to conduct standard welfare analysis in tightly specified general equilibrium models, with and without trading frictions, to see if some of Stone's arguments might be validated or overturned. Of course, there is no presumption a priori that government regulation of the type envisioned (or practiced) by Stone is warranted. Again, that is left as an open question. We shall return to some of these issues in the conclusion to this chapter.

Spanning, Futures Markets, and the Theory of General Economic Equilibrium

As Stone (1981) notes in his review of Arrow (1981), the standard theory of general economic equilibrium, as developed by Arrow (1964) and Debreu (1959), among others, helps us to understand what commodities need to be traded, in general, to ensure economic efficiency—that is, to achieve a Pareto-optimal allocation of resources. That theory is also a natural starting point for this essay because it includes no frictions or informational asymmetries; one would like to gain an understanding of futures markets without unnecessary complications, or at least to see if this is possible.

To begin, then, we shall consider the economy that is implicit in Arrow's discussion (1981). Imagine an economy inhabited by a finite number of households who live for a finite number of periods. Each household has preferences over finite-dimensional vectors of possible consumption commodities at each date as represented by a well-behaved utility function. Imagine also, for simplicity, that there is no production.

One can consider in Arrow's economy two possible trading regimes. In the first regime there is a complete set of competitive, date-contingent commodity markets. That is, there is a price system that specifies the number of units of money which must be surrendered, say to an exchange authority, for claims to each possible commodity at each possible date. Households take the price system as given and sue their initial allotment of money incomes to purchase such claims. Then, as the economy evolves over time, claims are honored and hosueholds consume accordingly. This trading regime can be interpreted as one with a complete set of futures markets, with maturities at every possible date. One the other hand, as Arrow notes, there is no trade in spot markets at any date, a somewhat damning feature.

In the second trading regime, hosueholds can trade their money incomes for claims on money at each possible date. Then, as the economy evolves over time, households receive their claims on money and use the money income to purchase commodities in the usual way. This trading regime can be interpreted as one with a complete set of active spot markets with the initial-date price system specifying the term structure of interest rates.

As Arrow argues, these two trading regimes are equivalent in terms of the final consumption bundles that are allowed in perfect-foresight competitive equilibria. That is, at equilibrium prices, the set of complete date-contingent commodity markets spans the same space as the set of complete bond markets with spot commodity trades. And, of course, under mild regularity conditions, the final allocation of consumption bundles is Pareto-optimal.

This observation is somewhat damning for commercial-purpose tests of futures markets. As Stone (1981) notes, it seems to imply that apart from bonds, futures markets are not needed. And, again following Stone, bonds futures would seem not to be needed because they are just futures on futures and introduce no new time element into the contingent-asset menu. However, one should be careful with these interpretations.

To proceed, we shall consider a private-ownership version of Arrow's economy, perhaps more consistent with Debreu (1959). In this version households have exogenously specified endowment vectors and there is no money as such. In the first exchange regime, then, there is a complete set of date-contingent commodity markets in which households trade claims on consumption goods, at specified prices, and there are no spot markets. In the second regime there is a complete set of initial-date markets in which households can trade claims on some numeraire, and there are complete and active spot markets at each date.

Obviously it is problematical as to how to interpret the claims on the numeraire in the second exchange regime. If one (arbitrary) commodity is taken as a numeraire, then the second exchange regime requires a futures market in one arbitrary commodity, with active spot markets. If one normalizes prices in the usual way, on the unit simplex, then the second regime seems to require some kind of index futures. The point, of course, is that one should not overinterpret the second exchange regime in the nonmonetary economy and, by the same token, one should not overinterpret the second exchange regime in Arrow's monetary economy. Without a theory of money—that is, a theory that prices money as a separate commodity—numeraires are indeterminate and so are the predictions of the theory. It is thus premature to use the theory for commercial-purpose tests of bond futures, for example. We shall return to this point again in the following sections.

Thus far there has been no mention of uncertainty, an aspect long thought to be essential to the existence of futures markets. But it is the fundamental insight of Arrow (1964) and Debreu (1959) that social uncertainty introduces no new complications into the theory of general economic equilibrium. One need only index commodities by fully observed states of nature, and theorems on the existence and optimality of competitive equilibrium, say for the first exchange regime, readily apply. But such social uncertainty would now seem to be damning to the existence of futures markets, for such markets allow the trade of uncontingent claims on commodities, whereas the theory would seem to predict the existence of markets in contingent claims on commodities, contingent on states. But it can be argued, following another insight of Arrow, that unconditional futures markets with active spot markets may well span the space of possible returns after all.

Arrow's insight (1964) is that one does not need, in general, a complete set of state-contingent commodities to achieve optimal allocations. To be specific, imagine an economy with one consumption date and S possible states of the world, and suppose, with Arrow, that households are endowed with money at some initial preconsumption date. Then the analogue to the second exchange regime is as follows. At the preconsumption date, households trade money for S possible securities, with security s promising to pay one unit of money if state s occurs and zero otherwise. Then, when states of nature are realized, delivered claims on money are used to purchase commodities in spot markets in the usual way. The allocation of consumption bundles that can be achieved in this way is equivalent with the allocation which can be achieved in complete, state-contingent commodity markets, and again the allocation is Pareto-optimal.

In lieu of these Arrow-type securities, now consider an exchange regime in which households trade unconditional claims on commodities in the preconsumption markets, claims that are valid independent of the state of nature that is realized, and suppose again the possibility of active spot market in every state. For such a futures market regime, Townsend (1978) has established an extension of Arrow's theorem, for a nonmonetary private-ownership economy. That is, if there are at least as many commodities as states of nature, and if the relevant matrix of equilibrium spot-market prices is full rank, the set of allocations that can be achieved with complete state-contingent commodity markets is equivalent to the set of allocations that can be achieved with the futures market regime. The point, of course, is that an unconditional claim on a commodity has a return contingent on the state, as spot prices can vary with the state. Under the rank conditions, the space of such returns is equivalent with the space spanned by Arrow-type securities.

This theorem seems to deal more kindly with the existence of futures markets than the comments of many authors concerning the absence of state-contingent securities or commodities. But the standard theory of general economic equilibrium would still seem to be missing many essential elements. First, the futures market regime may well be equivalent with the complete market regime, but there is nothing in the theory which predicts one over the other. Indeed, Ekern and Wilson (1974) and Radner (1974) have argued that equities or shares have a spanning property in a certain model, and Ross (1976) has made a similar argument for options. In general, financial structure is not pinned down by the theory. Putting this another way, there are no essential dynamics and no theory of financial assets such as money. Second, the theory does not make a distinction between futures markets and forward markets. All the markets are very much centralized. Third, there is no scope for an analysis of private information; uncertainty is social, not private. To evaluate Stone's first policy premise, and to some extent the second, one seems to need an abstraction in which private information is critical. Some of these concerns are addressed in the following sections, beginning with the explicit introduction of private information into the standard Arrow-Debreu paradigm.

Competitive Markets with Private Information

Expanded Commodity Spaces and Optimal Contract Design

To begin the discussion, imagine a world that allows for uncertainty in almost all aspects of economic life. Suppose, for example, each individual's endowment of consumption goods and factors of production is drawn from a well-specified probability distribution. Similarly, suppose production technologies are subject to random shocks, as are preferences or tastes. If the economy evolves over time, then suppose these shocks to endowments, technologies, and preferences are drawn from well-specified stochastic processes. Finally—and the key part of the specification—suppose that period by period each individual alone sees the realizations of his own endowments, preferences, and technology shocks.

In this world with asymmetric information, we may well imagine conducting economic analysis in the usual way—that is, in the obvious commodity space, with standard constructs or paradigms. After all, the addition of uncertainty does not alter the set of underlying commodities in the economy. Thus we might inquire, for example, about the operation of futures markets when deliverable supply of wheat is uncertain, with crop yields known only to the individuals themselves. But here again the indexation insight of Arrow and Debreu may well be applicable for both positive and normative purposes. That is, we might index commodities by all realizable states of nature or shocks and attempt to conduct standard competitive analysis in the enlarged commodity space.

There is, of course, a potential problem with this approach. Some states of nature (shocks) may be known only to the individuals themselves. If, for example, a contract specifies payment to a second party under contingencies known only to the first party, the first party may well claim that no such contingencies have ever occurred (see Arrow 1974 and Radner 1968). In short, in the terminology of Hurwicz (1972), allocations achieved by complete competitive contract markets, markets in completely indexed commodity bundles, may not be incentive-compatible.

To address these incentive information problems directly, we need to define first the set of allocations that are indeed achievable (both feasible and incentive-compatible) despite the existence of asymmetric information. And to avoid confounding the problems of asymmetric information with the problems of limited communication, we shall suppose that communication as such is unlimited, and that there are no other trading frictions.

Thus imagine that all individuals in the economy can communicate and trade with one another at no cost. That is, imagine that at the beginning of each period, after the realization of privately observed shocks to preferences, endowments, and technologies, each individual can send a message to some center or centralized market. There may be some a priori restrictions on the set of possible beginning of period messages for each individual. Next, in accord with some prespecified rule or outcome function, the beginning of period messages determine within period transfers may well be functions of messages sent at earlier dates. Finally, suppose each individual takes as given the sequence of a priori feasible messages spaces, one space for each period; the set of outcome functions, one for each period; and the period-by-period strategies used by all other individuals in the economy, mappings from previous (fully observed) messages and current (privately observed) shocks to current messages. Then each individual faces a well-defined decision problem and can determine a maximizing period-by-period strategy as well. These strategies then determine within period transfers or allocations as functions of realized shocks. It is imagined that in this process each individual makes full use of all available information. So we may term the outcome we have just discovered as a Bayesian-Nash equilibrium. (For a more formal treatment see Myerson 1979; Harris and Townsend 1977; 1981; and Townsend 1982).

If we examine the period-by-period allocations that result from a Bayesian-Nash equilibrium for any one of the class of resource allocation processes—that is, for any specification of message spaces and outcome functions—it becomes evident that those allocations satisfy certain restrictions. It is as if allocations were indexed by possible announcements of privately-observed shocks and are such that each individual announces privately observed shocks truthfully.[4] No such restrictions apply if more than one individual sees the same shock, or if privately observed shocks are completely deducible (for example, suppose endowment shocks were perfectly correlated across two individuals). In such cases, information is essentially public—individuals can be induced in a Nash equilibrium of some game to reveal the truth (this assumes no collusion, of course). But information that is truly private does have implications for resource allocation—arbitrary state or shock-contingent allocations are not necessarily achievable.

What implication does this rather abstract discussion have for the operation of competitive markets? To answer that question, we shall consider two rather extreme specifications. First, imagine a pure exchange economy with two types of individuals *a* and *b* and two underlying commodities 1 and 2. Households of type *a* have an endowment vector (8, 30) of the first and second commodities respectively and preferences as represented by the utility function

$$U_a = x_{a1}x_{a2} + \theta_a x_{a1} + 3x_{a2}$$

Here (x_{a1}, x_{a2}) is the consumption bundle and θ_a is a parameter drawn from a well-known distribution, namely $\theta_a = 8$ with probability $\beta = .5$ and $\theta_a = 32$ with probability $1 - \beta = .5$. Households of type *b* have an endowment (10, 10) and utility function

$$U_b = x_{b1}x_{b2} + \theta_b x_{b1} + 9x_{b2}$$

where $\theta_b = 12$ with probability $\alpha = .44$ and $\theta_b = 48$ with probability $1 - \alpha = .56$. The parameter θ_i is known to households of type *i* just prior to the time of trading, but not the parameter $\theta_j, j \neq i$. Finally, suppose there are a large (infinite) number of traders of each type.

Now suppose that there is a competitive (spot) market in which exchange of the two commodities can take place after the revelation of individual preference shocks. Then it is straightforward to compute competitive equilibrium allocations and utility levels for each of the four possible specifications of preference shocks. Allocations and utility levels are displayed in tables 9–1, and 9–2, respectively. Integrating down the columns of table 9–2, using the prior distribution over $\theta_b = (12, 48)$, namely $(\alpha, 1 - \alpha)$, one can compute the expected utility level of households of type *a* just before the opening of the market conditioned on the two possible values of θ_a. Similarly, integrating across rows in table 9–2, using the prior distribution over $\theta_a = (8, 32)$, namely $(\beta, 1 - \beta)$, one can compute the expected utility levels of households type *b*, just before the opening of the market conditioned on the two possible values of θb.

It may now be asked whether the competitive equilibrium parameter-contingent allocation is Pareto-optimal relative to the preferences of households just before trading. That is, is there an alternative parameter-contingent allocation that is better for households type *a*, conditioned on either value of θ_a, relative to its prior $(\alpha, 1 - \alpha)$ on values of the parameter θ_b, and similarly for households type *b*. A negative answer to the optimality question is provided by the Pareto-superior parameter-contingent allocation and levels displayed in tables 9–3 and 9–4, respectively.

Table 9–1
Competitive Equilibria with Spot Markets
Allocations

	$\theta_a = 8$	$\theta_a = 32$
$\theta_b = 12$	(12, 22)	(13.57, 14.40)
$\theta_b = 48$	(8.44, 28.6)	(10.25, 21)

(x_{a1}, x_{a2})

Table 9–2
Competitive Equilibria with Spot Markets
Utilities

	$\theta_a = 8$	$\theta_a = 32$
$\theta_b = 12$	426 / 342	672.85 / 396.97
$\theta_b = 48$	394.82 / 670.46	606.25 / 690.25

U_a/U_b

That the parameter-contingent allocation of table 9–3 is implementable is an implication of the preceding discussion above—there are many households of type *a*, so the parameter θ_a is essentially public information, and similarly for a parameter θ_b. The possibilities for preallocation communication (which here are unlimited) allow the competitive equilibrium allocation to be dominated.

This example has two implications. First, competitive spot markets as we usually model them may not be Pareto-optimal if there is asymmetric (but not private) information in the economy at the time of trading, though

Table 9–3
Parameter Contingent Allocations

	$\theta_a = 8$	$\theta_a = 32$
$\theta_b = 12$	(14, 26)	(12, 10)
$\theta_b = 48$	(7, 24)	(11.25, 25)

(x_{a1}, x_{a2})

Table 9–4
Parameter Contingent Allocations

	$\theta_a = 8$	$\theta_a = 32$
$\theta_b = 12$	554 / 230	534 / 522
$\theta_b = 48$	296 / 848	716.25 / 560.25

U_a/U_b

allocations are, of course, Pareto-optimal ex post by classical results. Second, there may be some gain to operating spot markets of a different kind, and there are certainly gains to operating a forward market before the revelation of preference shocks. In both instances commodities or contracts might be indexed by individually observed states of nature (again the preference shocks). This repeats the message of Arrow and Debreu. But it seems such contracts would need to be indexed to the announcements of all traders, including other traders of the same type, to provide incentives for correct revelation. By the same token, it is important that traders of the same type not collude in their announcements in an attempt to conceal their information. One is reminded of Stone's second policy premise, where potential abuses are associated with the concentration of information.

But how might standard competitive markets operate if there is information in the economy which is truly private? To examine this question, we shall consider a second, somewhat extreme specification. Imagine in particular an economy with one consumption date and ℓ possible commodities. Each individual has a strictly positive, ℓ-dimensional endowment vector e in the consumption period and preferences over ℓ-dimensional consumption vectors c as represented by a well-behaved utility function $U(c, \theta)$. Here the parameter θ is interpreted as a shock to preferences at the beginning of the consumption period, observed by the individual alone. For simplicity, suppose θ can take on a finite number of values in some set Θ. Suppose also that there is no aggregate uncertainty, that is, let λ (θ) be the fraction of households in the population who experience shock θ in the consumption period, some fixed constant. Knowing this, but little else, each individual regards $\lambda(\theta)$ as the probability of experiencing shock θ in the consumption period, with the expectation as of some prior planning period.[5]

In this economy, individuals will want to trade forward contracts in some planning period market, but they will want those contracts to be contingent on privately observed outcomes.[6] This may seem untenable, but it need not be so. Imagine a contract that calls for the exchange of one commodity for another, in specified amounts at specified prices, but that allows for options which are effected entirely by the individual. For example, the individual might default on the commitment entirely or offer only partial fulfillment. Indeed, we might well imagine that the amount of actual payment by the individual is determined in a probabilistic manner, as some legal system adjudicates claims, or that payment to the individual under another option is random as existing commodity supplies are rationed.[7] But whether or not the actual outcome is random, the individual will act in his own best interest, choosing which option to effect subsequent to the revelation his underlying circumstance—his shocks θ. This induces a natural ordering on outcomes relative to his θ-contingent utility function. Indeed, following the results of Harris and Townsend (1978, 1981), Myerson (1979), and Townsend (1982) described earlier, we may adopt an abstract, canonical representation for a contract, supposing that households make direct announcements of their shocks θ and that contracts are such that these announcement are made truthfully.

More formally, then, the previous economy with planning period contracts and individually effected contingencies is described as follows. First, for simplicity, restrict attention to a finite number of possible consumption bundles c. Then let $x(c, \theta)$ assign probability to consumption bundle c conditional on the announcement θ. The expected utility of the representative household is then

$$u(x) \equiv \sum_{\theta} \lambda_{\theta} \sum_{c} x(c, \theta)\, U(c, \theta)$$

The consumption possibilities set is

$$\bar{X} = \{x\colon x \geq 0, \sum_c x(c,\theta) = 1 \text{ for each } \theta$$

and

$$\sum_c x(c,\theta)U(c,\theta) \geq \sum_c x(c,\phi)U(c,\theta) \quad \theta, \phi\}$$

Thus $\bar{X}$ ensures that the $x(\cdot,\theta)$ are probability measures and that preference shocks are revealed truthfully. Thus $\bar{x}$ defines the set of allowable contracts.

Imagine that any contract in $\bar{X}$ can be purchased in a competitive, planning period market, as if each of its components were priced separately. That is, let $p(c,\theta)$ be the price of the $x(c,\theta)$ component in terms of some abstract unit of account. Each individual is effectively endowed with some contract ξ in $\bar{X}$, a vector of probability measures putting mass one on the endowment e for all $\theta \in \Theta$, that is $\xi(e,\theta) = 1$ for all $\theta \in \Theta$ and $\xi(c,\theta) = 0$ for all $c \neq e$, $\theta \in \Theta$. Thus the individual maximizes utility $u(x)$ by a choice of a contract x in $\bar{X}$ subject to the budget constraint

$$\sum_\theta \sum_c p(c,\theta)x(c,\theta) \leq \sum_\theta \sum_c p(c,\theta)\xi(c,\theta)$$

One might also imagine there are intermediaries (firms) in the economy that make plans (in the planning period) to buy and sell consumption goods. An intermediation choice $y(c,\theta)$ specifies the number of units of the bundle c that the intermediary plans to deliver or sell to the market for use by households announcing they are of type θ. Thus, if $y(c,\theta)$ is negative, there is a plan to take in or buy resources. The intermediation set Y is defined by

$$Y = \{y(c,\theta)\colon \sum_\theta \lambda(\theta) \sum_c c y(c,\theta) \leq 0\}$$

so that the intermediary can not deliver more than it takes in. Note that Y displays constant returns to scale, so we may act as if there were only one intermediary. The intermediary takes prices as given and maximizes profits

$$\sum_\theta \sum_c p(c,\theta)y(c,\theta)$$

constrained by the set Y.

Finally, a competitive equilibrium is a specification of contract choice $x(c,\theta)^*$, intermediation choice $y(c,\theta)^*$ and a price system $p(c,\theta)^*$ such that first, the contract choice is utility-maximizing given the price system; second, the intermediation plan is profit-maximizing given the price system; and third, markets clear—that is $x^*(c,\theta) - y^*(c,\theta) = \xi(c,\theta)$ for each c and θ. It may be verified that the third market-clearing condition in conjunction with intermediation set Y is equivalent to the condition that the economy-wide average consumption not exceed the economy-wide average endowment. That is

$$\sum_\theta \lambda(\theta) \sum_c x(c,\theta)c \leq e$$

The competitive contract markets just described may seem difficult to interpret. After all, as with standard competitive analysis, nothing has been said about the price determination or market assignment processes. That is, it is not clear from where prices come or who trades with whom, so one might be tempted to argue that this is not a useful abstraction. But imagine a market made up of a number of brokers who compete with one another, specifying the terms of contracts and calling out terms of trade or prices. These brokers attempt to attract household customers, pooling risks and in effect acting as the intermediaries just described. Of course, these brokers-intermediaries are really just households themselves, trading on their own account. One might well imagine, then, that the outcome of this process will resemble the competitive equilibrium allocation and price vector as the number of households (and potential brokers) gets large.[8]

Prescott and Townsend (1982a) have established both the existence and optimality of competitive contract market equilibria in environments that include the one just described as a special case. Indeed, the general analysis allows for ex ante privately observed diversity, and arbitrary (finite) number of trading dates, and private information at each date. In general, the equilibirum contracts will involve random components; they are used to discriminate (distinguish) among households with privately observed heterogenous characteristics. Finally, the analysis reduces to standard Arrow-Debreu general equilibrium theory when the information structure is private but not sequential.

The positive and normative implications of the work are apparent. From a positive standpoint, it seems we might expect to observe competitive markets in contracts with individually effected contingencies.[9] From a normative standpoint, it seems such markets would have desirable characteristics. This may have a direct bearing on commercial purpose tests.

There is, however, an important qualification to this entire discussion. If households with characteristics that are distinct and privately observed at the time of initial trading do not enter the economy-wide resource constraints in a homogenous way, there can be problems for the existence and optimality of competitive contract markets. Such problems will occur in the preceding example if there is some statistical dependence in preference shocks, so that households have some asymmetric information on their own future shocks at the time of initial trading. Indeed, as Prescott and Townsend (1982b) argue, these are precisely the problems that lead to difficulties in the insurance market models of Rothschild and Stiglitz (1976) and Wilson (1977) and the signaling models of Spence (1974). It seems clear from these results, and from what is now an enormous literature, that our standard conception of what might constitute a competitive market in such situations may well have to be altered. Thus there may indeed be some scope for intervention or control, though that question is still open. But by the same token, these problems do not emerge if trade occurs in forward contracts before the arrival of private information.

In conclusion, I have argued that when there is private information, standard views on what are natural commodities or contracts to be traded may need to be altered. We have made some progress in understanding when there may be problems for the operation of competitive markets under private information and whether those problems can be remedied by contract design or maturity structure. Still, there remain many observations and issues that cannot be addressed by the constructs of this section. For example, many of the issues raised by Stone's first policy premise remain unaddressed. The reason is also apparent: Despite the existence of private information, the competitive markets described in this section are highly centralized—the communication technology allows a great deal of information to be transmitted and, consequently, there is a great deal of implicit coordination across individual traders. For example, there is no possibility for markets for individual insurance as distinct from forward markets. Neither can the constructs of this section address issues of market formation and the role of price discovery mentioned in Stone's fourth policy premise, nor can they address issue concerning monopoly power on the part of exchanges or issues of self-regulation on the part of exchanges, as in Stone's third policy premise. Finally, the constructs of this section still do not allow money or the existence of financial assets in the usual sense of the term. Thus, we turn next to alternative means of breaking up the Arrow-Debreu paradigm—namely, limited communication.

Coordination Problems in Decentralized Models of Exchange

Uncoordinated Trade and the Gains from Market Formation

It seems useful to begin this section with a model in which there are no centralized markets whatever—traders search for one another in a random

fashion, and exchange takes place on a haphazard basis. A characterization of the equilibrium of that model makes clear the type of coordination problems that can emerge—there are multiple equilibria, and the equilibria are in general nonoptimal. We shall then retain some of the search frictions of that model, but allow a centralized exchange. As might be expected, the problems disappear but new issues are raised.

Diamond (1982) constructs a model that poses the coordination issue nicely. Imagine a tropical island with many individuals. When unemployed, each individual strolls the beaches examining palm trees. Some trees have bunches of coconuts, but the height of the bunch above the ground varies from tree to tree. More generally, individuals are imagined to learn of production opportunities as if opportunities were generated by a Poisson process, with arrival rate a. That is, $a \cdot \Delta t + \sigma(\Delta t)$ is the probability of finding a production opportunity during interval of time Δt, where $\sigma(\Delta t)$ is a second-order term that is negligible relative to Δt for small Δt. Thus a is interpreted as the probability of finding a production opportunity per instant of search. Each opportunity has y units of output and costs c units to produce. Output y is the same for all projects but c varies across projects with cumulative distribution G.

Now suppose individuals cannot eat the fruit of their own labor. So having climbed a tree, the employed individual sets out in search of a trading partner to trade nuts for nuts. But trading partners are encountered at random, and one is more likely to encounter a trading partner the higher is the fraction of individuals on the island who are also searching for trading partners. More generally, suppose that the arrival of trading partners is also a Poisson process with arrival rate $b(u)$, with $b' < 0$, where u is the fraction of the unemployed population searching for trees.

The only decision in this model is the height of trees to climb—that is, some critical c^* above which production opportunities are foregone. The higher is c^*, the greater is the instantaneous cost. On the other hand, with nuts in hand, eventual consumption is made possible, with the utility of consumption discounted at rate r; the utility function is otherwise linear, increasing in consumption and decreasing in costs c. Thus, as might be expected, the more likely is an encounter with a trading partner, the greater is the gain from having nuts in hand, and thus the higher will be the choice of critical value c^*.

It is now apparent how this model can generate multiple equilibria. If everyone decides to climb relatively high trees (that is, engage in costly production), a large fraction of the population will be searching for trading partners in a given instant. This, in turn, can rationalize the decision to climb high trees. On the other hand, equilibria with relatively low levels of economic activity are viable as well. More formally, with parameter a interpreted as the fraction of unemployed individuals in the population who encounter production opportunities in any instant, $G(c^*)$ as the fraction of such individuals who decide to produce in that instant, and $b(u)$ as the fraction of employed individuals who encounter a trading partner in any instant, the unemployment rate satisfies

$$\dot{u} = b(u)(1 - u) - auG(c^*) \tag{9.1}$$

with the maximizing critical value c^* satisfying

$$c^* = \frac{by + a\int_0^{c^*} c}{r + b + aG(c^*)} \tag{9.2}$$

Plotting equation 9.1 at $\dot{u} = 0$ and 9.2 yields figure 9-1 (after Diamond 1982). Any crossing of the two curves in figure 9-1 constitutes a stationary equilibrium.

It is also now apparent why equilibria are nonoptimal. No individual takes into account that his decision to climb a tree and search for a trading pattern has a beneficial impact on the others who are also searching. That is, $b'(u) < 0$, but each individual takes $b(u)$ parametrically. The model has positive externalities. More formally, take the social welfare critierion to be discounted average (per capita) utility,

$$W = \int_0^\infty e^{-rt}Q(t)dt$$

where

$$Q(t) = b(u)(1 - u)y - au\int_0^{c^*} cdG,$$

and where $b(u)(1-u)$ is interpreted as the rate of sales in the population at each instant in time, with consumption y per sale, and with $auG(c^*)$ as the

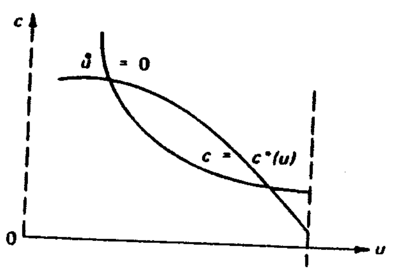

Figure 9-1. Diamond's Search Model: Multiple Equilibria

average rate of production, with an average cost $\int_0^{c^*} G/G(c^*)$ per unit of production. Then the maximization of W with respect to c^* yields

$$c^* = \frac{by - b'(1 - u)y + a\int_0^{c^*} cdG}{r + b - b'(l - u) + aG(c^*)} \tag{9.3}$$

Generally, equations 9.2 and 9.3 are inconsistent. In fact, at an equilibrium level c^*, $\partial W/\partial c^* > 0$ so that locally there is too little activity in the economy.

Diamond's model raises clearly an essential coordination issue. How is a decentralized equilibrium to be effected? Any such equilibirum has self-fulfilling expectations, but there are multiple equilibria. So how is it that individuals come to know that others are climbing high trees, so that the unemployment rate is low, for example. The search process seems to suppose a complete absence of communication across individuals.

As Diamond emphasizes, this coordination problem arises because of the undirected nature of the search process. To see this more clearly, suppose that somehow or other all individuals believe that others are taking their nuts to a centralized exchange market at a known location.[10] Retaining some of the frictions of search for trading partners, suppose each individual with a nut to sell arrives at the exchange market as if under a Poisson process, with arrival rate b some constant. Then it is readily verified that there is, in general, a unique equilibrium, because the maximizing c^* is no longer an implicit function of the unemployment rate (see figure 9-2).

It is also immediate from equations 9.2 and 9.3 with $b' \equiv 0$ that the unique equilibrium is the unique social optimum. Finally, note that $(1 - u)b$ is the nonzero fraction of agents in the population who arrive at the exchange center in any instant, so there is continually some market activity. Having arrived, though exchange is instantaneous and empty-handed, individuals then reinitiate the search for production opportunities. As a result, there is nontrivial frictional unemployment. (For that outcome, we may just have well let $b = 1$.)

To suppose the existence of on centralized exchange market in Diamond's model is to beg an obvious question related to the coordination problem. How is it that individuals come to know that others are traveling, when employed, to a specific location? Again, communication among individuals is apparently precluded a priori. The model without a centralized exchange seems to cry out for such institutions, but we do not have a theory that explains how such institutions come about. As it turns out, related issues are raised by Mortensen (1974) in which there are a finite number of possible locations for exchange markets. The welfare analysis in Mortensen is even more problematical.

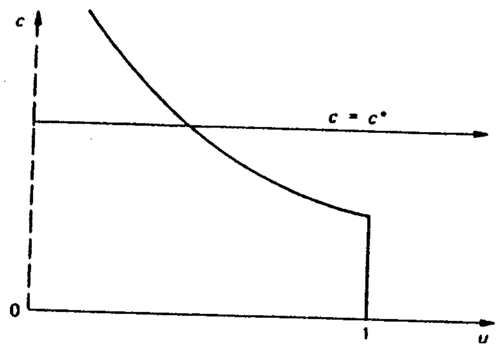

Figure 9–2. Diamond's Search Model: Unique Equilibrium

A Problem of Cross-Market Coordination

Imagine with Mortensen a pure exchange economy with ℓ commodities, m potential markets, and n traders. Each trader has a nonzero endowment vector of commodities and has preferences over consumption vectors as represented by a continuous, strictly concave, and strictly increasing utility function. For our purposes, we shall suppose there is only one trading date, though Mortensen gives his model a more dynamic interpretation. Finally, we shall restrict attention to a special case of Mortensen's model and suppose that every trader can choose to participate in any (one) market and that every commodity can be traded (potentially) in each market.

Each of the markets is assumed to function in the standard way, as if there were a Walrasian auctioneer given the traders who choose to participate in that market. Thus there arises an ℓ-dimensional price vector that clears the market in all commodities, given the excess demand functions of each of the traders who have congregated there. But choice of markets is endogenous—each trader can choose at most one market at the beginning of the period before knowing the choices of others.

Now suppose that for some reason or other a given trader imagines that all others are choosing markets at random, say each market with probability $1/m$. Then given the price formation and allocation rules, all markets look alike to the given trader a priori. And thus he too may just as well choose a market in this random fashion. In short, we have just described a Nash equilibrium in market-choice strategies. Alternatively, suppose the given trader imagines that all others are choosing some one particular market. Then the given trader will generally want to choose that same market (at least there can not be a better strategy). The reason for this is clear. If a

trader chooses a market in which no one else participates, the price formation and allocation rules imply that he will end up consuming his endowment. Thus we have described a second Nash equilibrium in market-choice strategies.

It thus seems that if market formation is endogenous, in the sense that it is in Mortensen's model, there can arise multiple equilibria. And, as intuition might suggest, an equilibrium with random market-choice strategies can not be Pareto-optimal. Suppose we were to give to each trader that allocation which is the mean of his random allocations in the Nash equilibrium with random strategies. Then the new economy-wide allocation is feasible and, with risk aversion, Pareto dominates the equilibrium allocation.

The existence of multiple equilibria in Mortensen's model raises again the question of how any equilibrium is to come about without extramarket control or coordination. And the undesirable randomness associated with at least some equilibria would seem to give impetus to coordination efforts. But some caution is in order, for the obvious policy intended to coordinate market choices and remove undesirable randomness may not benefit all traders. One might contemplate, for example, in Mortensen's economy, the legal prohibition of trade in all markets save one, if somehow or other such an agreement could be effected (recall again that a priori communication is precluded). It is trivial that there can be no randomness in the resulting allocation; we have merely replicated the second equilibrium described above. Indeed, as all trade takes place in a standard Walrasian market, the resulting allocation will be Pareto-optimal.

But that allocation need not Pareto-dominate the random allocation of the first equilibrium. To see this, consider first a somewhat extreme case and suppose that the prices of a centralized Walrasian equilibrium are such that at least one trader does not trade at all. In contrast, the Nash equilibrium with random market-choice strategies by all traders will produce a random price in each market (and a dispersion of prices across markets ex post) and thus would offer in general the possibility of beneficial trade with positive probability, as Mortensen notes. This result is clearly more general, and the result bears repeating. In the absence of centralized markets, a move in the direction of centralization need not be uniformly welfare—improving.[11] Some traders may be hurt. We might expect them to oppose such a move.

Again, Mortensen's model suggests a need for some extramarket coordination if any of a number of essentially equivalent markets can operate simultaneously. That is, some (centralized?) decision may be needed on which markets ought to be active. And if some are already in operation, an equitable scheme might involve some compensation to existing or potential traders, not to mention brokers. We might well ask whether these coordination problems would disappear in a setting in which the number of markets is fixed and in which traders have no choice among markets whatever. As it turns out, there still can be problems if decisionmakers face nontrivial intertemporal decisions. Indeed, these problems bear on the issue of the existence of organized exchanges, much as Telser (1981) has argued.

Liquidity, Coordination, and the Existence of Organized Exchanges

Telser (1981) argues that organized futures markets exist, as distinct from forward contracts, because of liquidity considerations. He draws an analogy between futures contracts and money and suggests that we would not want futures in all commodities. He also argues that organized exchanges that allow more anonymous dealing among traders enhance the liquidity of futures contracts. Not surprisingly, many of Telser's arguments have formal analogues in some recent work on endogenous inside and outside monies.

To begin, imagine a world with just two trader types and one consumption good. Suppose that all traders of type A begin life with zero units of the consumption good and face an endowment sequence that alternates period by period, say (0, 1, 0, . . .). Similarly, suppose that all traders of type B begin life with one unit of the consumption good and face the endowment sequence (1, 0, 1, . . .). All traders have identical preferences, described by the time-separable discounted utility function

$$\sum_{t}^{\infty} = \beta^t U(c_t^i)$$

where c_t^i is the number of units of consumption of a trader type i at date t. There is supposed to be no storage and no production.

Suppose now that there are a fixed number of markets and that each trader visits one market in each period of his life in a fixed sequence. In particular, imagine that each trader is traveling on some spatial plane, as if on a highway or turnpike, either east or west, as indicated in figure 9–3. The arrows indicate the direction of travel and the spikes indicate markets. The numbers 0 and 1 index the endowment of a trader at the indicated position. Initially, at $t = 0$, there is one representative agent at each position, and each trader moves forward one market in each period.

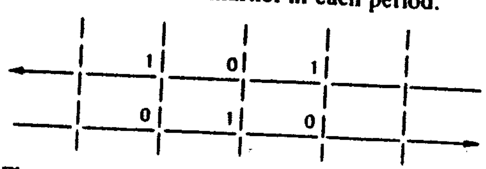

Figure 9–3. Markets with Anonymous Traders

This model is constructed in such a way that when two traders meet in at any market at any date they are completely anonymous; that is, the two have never seen each other before and will never see each other again. An implication of this is that there can be no private debt. No IOU can be redeemed by any issuer. Thus, there can be no inside financial assets. There are no objects that when acquired provide liquidity in subsequent periods and no objects that give the ability to purchase the consumption good in hard times when the endowment is low.

Some such liquidity can be provided with fiat money. In particular, suppose there were pieces of paper in the previously described economy that represent outside indebtedness, pieces of paper that are never redeemed. Still, on the expectation that this money will maintain its value relative to the consumption good, some of it can be acquired in good times when the endowment is high and passed along in bad times. Indeed, Townsend (1980) establishes for precisely this model that there exists a monetary equilibrium with that property. Again, money provides liquidity in a world where traders are anonymous. It allows mutually beneficial trade, an improvement over barter (here barter is equivalent with autarky).

We may now ask whether privately issued securities might also provide liquidity in a slightly modified world in which traders are not so anonymous. Suppose, in particular, that the previously described turnpike is connected end to end, as if traders were on a merry-go-round or circle. Then, as discussed in Townsend (1980, section 5), there is an equivalent canonical model in which traders meet one another repeatedly (see table 9–5). Indeed, one may as well allow endowments and preferences to be more general and consider an example economy in Townsend and Wallace (1982), in which there are four trader types. In it, traders type 1 and 2 are paired at date 1, in some location 1, and traders 3 and 4 are paired at date 2, in some location 2. Traders 1 and 4 stay at their respective locations during each period, and traders 2 and 3 alternate locations period by period. Finally, for simplicity, it may be supposed that the economy lasts only 4 periods.

Table 9–5
A Townsend-Wallace Economy

	Location	
Date	1	2
1	(1,2)	(3,4)
2	(1,3)	(2,4)
3	(1,2)	(3,4)
4	(1,3)	(2,4)

Privately issued securities are viable. Indeed there is now the possibility of direct bilateral loans for the traders who are paired at dates 1 and 3 and at dates 2 and 4. In a sense, these loans provide some liquidity. On the other hand, they are always held by the original acceptor until the redemption date. They may be thought of as forward contracts. More interesting perhaps is the possibility of securities that are traded before redemption dates, such as a promise issued by trader 1 at date 1 and location 1 to pay the consumption good at date 4 in location 1. This security or futures contract is passed from trader 1 to trader 2 at date 1, from trader 2 to trader 4 at date 2, from trader 4 to trader 3 at date 3, and presented for redemption by trader 3 at date 4. That is, with each of our traders types taken as representative of a large number of identical individuals, this model can be interpreted as implying the existence of active secondary (or futures) markets.

Townsend and Wallace (1982) establish for this example economy that the existence of active secondary markets in general. But they also encounter another apparent coordination problem. The consumption allocations of any perfect foresight equilibrium can be supported with a variety of security trades, trades that seem to require some communication or coordination at a time across the two spatially separated markets. It is enough, for example, that traders 1 or 2 issue 4-period securities at date 1, or that traders 3 or 4 do so. If both pairs do so, then the amounts should be constrained to satisfy a certain equation, but there seems to be no reason for that to occur. Indeed, it is hard to see how it can occur in the absence of communication across markets, communication that was apparently precluded a priori. As with the multiplicity of the models of Diamond and Mortensen, this result is highly suggestive of the need for some (centralized?) decision on which security markets should be active and which not or for some institution that coordinates trade across markets. And here at least the welfare analysis is straightforward; one equilibrium is as good as any other. The only issue is how an equilibrium is to be attained.

One last point can be made in the context of the present model. Suppose the economy posed in table 9–5 lasts just 2 periods. Then, again, there can be no privately issued securities as no security can be redeemed. And of course this is so even if, for example, traders 1 and 4 would like to borrow from traders 2 and 3, respectively, in an entirely symmetric fashion. But now suppose that somehow or other traders 1 and 4 form a syndicate or trading cooperative and that a commitment made by any member of the cooperative is equivalent with a commitment made by all. Then trader 1 might borrow from trader 2, making a commitment for the syndicate (1, 4) to pay back the loan and similarly for traders 4 and 3. That is, trader 1 borrows on his own account from the syndicate (1, 4) and 2 lends to the syndicate (1, 4). The books of the syndicate balance. Then at the second date, when traders 2 and 4 meet, 4 honors the commitment (of 1) and similarly for trader 1. That is, 4 pays back the syndicate (1, 4) by in effect paying 2. Again, the books of the syndicate balance.

Of course, with the formation of such syndicates, the 2-period loans increase in liquidity. They more represent money because they are used in exchange with a person who is anonymous. More generally, in the Townsend-Wallace terminology, the formation of syndicates leads to more chains of pairings that lead from an issuer (or his trading syndicate) at some specified date and location to the issuer (or his syndicate) at the designated redemption date and location. In short, syndicates serve as go-betweens or intermediaries; one does not have to track down the original issuer, or a third party who will be linked eventually (or indirectly) with the original issuer, to break a commitment.

The formation of trading syndicates raises another issue, however. Are large syndicates, which otherwise would seem to be advantageous, necessarily associated with market power or elements of imperfect competition? That is, some coordination or communication appear to be beneficial in this environment with frictions or barriers to trade. But this coordination should not be done collusively, in the sense that Adam Smith had in mind. One is reminded of Stone's third policy premise.

In a sense, though, this discussion of exchange syndicates is premature. In the Townsend-Wallace (1982) model, as well as the model of Mortensen (1974), markets or trader-pairings are specified a priori and are not subject to alteration. That is, there can be centralized communication within markets or pairings but there is supposed to be no communication across markets. To discuss exchange syndicates, then, or market formation more generally, or indeed to discuss the formation of extramarket control devices, one seems to need a model in which trading frictions exist but can be overcome at some cost—that is, a model with variable but costly communication. In what follows, two such models are presented. (However, these models are particularly stylized and are only intended to suggest results that might follow in more elaborate setups.)

On Limited Communication, Self-Regulation, and Exchange Rules

First, we describe a model with costly matching (see Mortensen 1982, and the antecendents in Diamond 1980; Diamond and Maskin 1979; and Mortensen 1979, among others). It is also closely related to the Diamond (1982) model presented previously in this chapter.

Imagine a world with two trader types, n_i of type i, $i = 1, 2$. Each unmatched trader of type i seeks an unmatched trader of type j to exploit some joint opportunity or to engage in exchange. Let λ_i denote the search intensity of an unmatched trader of type i, where $\lambda_i dt + \sigma(dt)$ is the probability of contacting an agent of the opposite type during a short time dt long (here $\sigma(dt)$ is a second-order term). Thus λ_i is interpreted as the probability of such contact, made by trader type i per unit time or per instant. Assuming contacts are made at random, $q_j = (n_j - m)/n_j$ is the probability that the trader contacted by i is unmatched, where m is the number of matched pairs. Consequently, the probability of a successful contact made by i per instant is $\lambda_i q_j$. Now number $(n_j - m)$ traders of type j are also searching for a match with intensity λ_j. Thus, a trader of type i may be contacted in this manner with probability $[(\lambda_j)(n_j - m)]/n_i = [n_j q_j \lambda_j]/n_i$. Adding probabilities, the probability of successful contact for an unmatched trader of type i (however generated) is

$$\frac{q_j}{n_i}[n_i\lambda_i + n_j\lambda_j] \equiv h_i(\lambda_1, \lambda_2)$$

Here it is apparent that the probability of successful contact varies positively with the search intensity of traders of the opposite type.

The instantaneous (per unit time) cost of search intensity λ_i for trader type i is $c_i(\lambda_i)$, where $c(\cdot)$ is a nonnegative, increasing, strictly convex function. The benefit of search depends on both the random time to match, which is endogenous, a function of λ_1 and λ_2, and the division of the value of the match. As regards the latter, suppose the capital surplus of any match is divided equally between the two members, as it would be in Nash's solution to the obvious bilateral bargaining game. Thus, letting V_i denote the value of utility payoff of continued search in the present model for a trader of type i—that is, the discounted present value or utility payoff for any unmatched trader of type i, the value of a match for a trader of type i is $V_i + \frac{1}{2}(B - V_1 - V_2)$ where B is the direct joint payoff of gain from a match, some constant. Thus, if the future match takes place at date t, the discounted present value is

$$\Pi_i(t) \equiv e^{-rt}[V_i + \tfrac{1}{2}(B - V_1 - V_2)] - c_i(\lambda_i)(1 - e^{-rt})/r$$

where r is the discount rate. And thus, with the random time to match as negative exponential

$$V_i(\lambda_i, \lambda_j) = \int_0^{\infty} \Pi_i(t)h_i(\lambda_1, \lambda_2)\exp(-h_i(\lambda_i, \lambda_2)\, t)\, dt$$

(Here both the number of participants, the n_i, and the fractions of unmatched agents of type i, the q_1, are taken as fixed and stationary.)

In a noncooperative equilibrium, each trader of type i takes the search intensity of the other type, λ_j, as given. Thus a Nash equilibrium is a specification of search strategies $(\lambda_1^*, \lambda_2^*)$ such that

$$V_i(\lambda_i, \lambda_j^*) \leq V_i(\lambda_i^*, \lambda_j^*) \quad \text{for } i = 1, 2 \quad j \neq i$$

As in earlier work, Mortensen finds that a noncooperative equilibrium is necessarily inefficient. That is

$$\frac{\partial V_i(\cdot)}{\partial V_j}\lambda^* > 0$$

The intuition is straightforward: The value of the game to both agents increases with search intensity because time to match falls and both agents share in the surplus when a match forms.

Mortensen (1982) also establishes that this externality can be internalized if the trade type responsible for the match, say type i, is given the entire surplus of the match less a compensation to the other trader equal to the latter's foregone value of continued search—that is, is given $B - V_j$. Then, not surprisingly, the noncooperative equilibrium with this new allocation rule will maximize the joint wealth of the typical unmatched pair and in that sense is optimal.

As Mortensen notes (1979), these results raise a troublesome enforcement issue. Under the second allocation rule, no trader when contacted by another has an incentive to agree to the specified division of the surplus. Nor is it clear how unmatched traders can precommit to one another because they are indeed unmatched. Thus, in the present model, there again seems to be a suggestive role for additional coordination, some agreement concerning a priori rules of exchange. The model does not suggest how such an agreement might come about.

Thus far we have avoided an analysis of the effect of competition among members of one class of traders for potential exchange with members of the other class. Perhaps one's intuition is that such competition would be beneficial. But in the context of a model with limited and endogenous communication, that need not be the case as a model of Boner (1981), following Butters (1977) points out.

Imagine after Boner a static pure exchange economy with two commodities and two classes of traders, say bidders and searchers. Each class has a continuous and strictly increasing utility function that may vary across types. In addition, the endowment allocations are extreme. The bidders have all of one commodity, the searchers all of another.

Each of the set of bidders can send a message (advertise) an admissible trade in the two consumption goods. Any individual message is received by at most one of the searchers, and falls on each searcher with the same or uniform probability. Each searcher chooses a utility maximizing bid from the set of bids received (randomizing if there are ties).

Boner seeks to characterize a noncooperative Nash equilibium in the choice of messages or bids. He discovers a sense in which noncooperative equilibria necessarily involve random strategies among the bidders, leading to a nonatomic bid distribution. But the Pareto optima for the economy, allowing for coordination of bids, are typically atomic bid distributions. Thus, competition among bidders would seem to be socially inefficient. We again see a potential gain for cooperation among advertisers or brokers in models with limited communication or costly exchange. But again unlimited cooperation at the very least implies a skewed distribution of income (welfare). It is not clear that self-regulation would be socially desirable. Of course, one might note that in Boner's model the bidders are given an exogenous communication advantage.

Concluding Remarks

The enforcement of contracts, property rights, and rules concerning the operation of competitive markets has long been regarded as a proper role for government. But which contracts, rights, and rules? This chapter argues that we might well address such questions in the context of highly stylized general equilibrium models of the economy. In effect, such models offer a laboratory in which we can inquire as to the effect of trading frictions, such as imperfect information and limited communication, and attempt to pinpoint features of the economy that may prove crucial.[12] The idea is to search for an optimal social arrangement in the context of models with such frictions and to take as the role for government the enforcement or implementation of such an arrangement. In short, following Lerner (1944), government should do no more than enforce the collective sentiment of the individual citizens.

Is there an active role for government to play? The decentralized models given previously seem to suggest a coordination role for government, but exactly what that role should be remains unclear. After all, it is never said how some outside agency can come to play a coordination role that is infeasible for private individuals. Indeed, the government cannot do that in the models as specified. More generally, it seems useful to bear in mind Lerner's distinction between control (that is, the implementation of the social optimum in a thorough manner but with a minimum of complexity in regulation) and contemporary regulations as he perceived them in industrial countries. The question of whether regulatory agencies are indeed organized in the social interest is still open, but rigorous welfare analyses along the lines of this chapter may help to begin to answer that question.

Two areas of future research seem deserving of immediate attention. First, we need models in which third parties or groups of agents play explicit intermediary roles in exchange. Indeed, that result was suggested by Mortensen (1979) as a way to internalize the externalities associated with his matching process. And many of the other models described here suggest a gain to cooperation among individuals, something that is impossible in the models as formulated. In the end, we seem to be led to a model in which groups or exchange syndicates compete with one another and perhaps to some modified version of the core as a useful equilibrium notion.[13]

Second, the models of this paper do not yet seem capable of addressing many of the issues raised in Stone's first policy premise. Private information alone is not enough, as I make clear earlier. More decentralization is needed. A synthesis of models with private information and limited communication would seem to be a promising direction for future research.

Notes

1. See Townsend (forthcoming) and the literature cited therein.
2. No attempt is made here to survey the literature on futures markets or futures market regulation (see the references cited in Telser 1981 and the volume containing Arrow 1981 and Stone 1981 for a start). Edwards (1981) also argues that we should be clear about which frameworks we have in mind when contemplating futures market regulation.
3. Again, no attempt is made here to offer a complete review of all relevant general equilibrium models. The models offered here are intended to be suggestive and to provoke further thought.
4. Here and later attention is restricted to economies with privately observed shocks to preferences. These may be interpreted as shocks to an underlying household production function. General extensions to explicit technology and endowment shocks are possible, but more awkward.
5. For a formal justification of this specification see Bewley and Radner (1980).
6. Of course, trade in spot markets would be mutually beneficial ex post, but spot trades alone do leave ex ante risk and the desire for some kind of insurance. Hereafter, following the usual Arrow-Debreu treatment of uncertainty, ex post spot markets are precluded without loss of utility.
7. To some extent actual futures contracts have these characteristics. See note 9.
8. Again, this conjecture is based on Townsend (forthcoming).

9. Indeed, a futures contract is not a simple, noncontingent agreement to buy or sell a specified commodity. For potatoe or for crude oil futures, the buyer or seller have various options, including the method, place, and exact date of delivery. If the agreed-on delivery specification proves impossible in crude oil futures because of an act of God or various specified events, a new set of options comes into effect. In potatoes futures, default terms are included. Default charges depend on contract value (last settling price for the delivery month), though they can be waived or reduced by the exchange if delinquency in performance is viewed as beyond the control of the delinquent party or if there are mitigating circumstances. Margin calls must be met within a reasonable time and if not met give the carrying broker the right to close out all or part of the open trades until any remaining unliquidated contracts are fully margined.

10. The possibility of organized location-specific markets was suggested by Robert E. Lucas, Jr., in a discussion of Diamond's paper in a conference on transactions costs at the University of Pennsylvania.

11. Again, this is the theory of second-best.

12. Lucas (1980) makes the case for this scientific method in analyzing business cylces.

13. Again, see Townsend (forthcoming).

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Comment

Lester G. Telser

Professor Townsend's paper touches on many of the important and classical problems of economic theory. It shows the close connections between these problems and those which arise in the theory of futures markets. Townsend begins by asking whether we can have a pure futures economy without any spot markets. This question first began to be discussed in the debate about the feasibility and efficiency of a centrally planned economy. Barone was the first to pose the question in modern economic theory and there are important contributions by Lange, Hicks, and Lerner. Hicks in particular drew to the attention of economists to the relationship between spot and futures markets. The existence of uncertainty made it necessary to have spot markets, according to Hicks. This results from the desires of those who have entered into futures contracts to reverse their commitments by transacting in the spot market because events they have not foreseen make this desirable. Therefore, according to Hicks, it was not possible to eliminate all the consequences of a lack of coordination in a sequence of spot markets by having futures markets in their place. It would be helpful if Townsend had included a discussion of Hicks's contributions to this problem.

Townsend correctly points out that Arrow and Debreu gave a theoretical solution to this problem of uncertainty by introducing the concept of state-contingency contracts. Townsend gives the impression that futures contracts in particular are not state-contingent and, more generally, that there are few actual instances of state-contingent contracts. I find myself in disagreement. Many if not all insurance contracts are state-contingent contracts. The party issuing the insurance—that is, the one who sells the contract—agrees to make a payment to the buyer of the contract, the one who obtains the insurance, under prescribed conditions. The biggest obstacle to the more widespread use of these contracts is moral hazard. It may be very costly to determine whether or not there has been fraud so that the insured party has more or less deliberately brought about the event that would cause the issuer of the insurance to make payment.

Take fire insurance on a house, for example. The issuer of the insurance usually imposes an upper bound on the amoung of the payment he will make in case there is a fire that is below the market price of the house. The reason is obvious. Similarly, other conditions set limits on the obligations of the parties to a futures contract. Usually they give the circumstances under which one of the parties no longer has the obligation to fulfill the contract. Therefore, futures contracts do have elements in common with state-contingent contracts. Indeed, virtually all transactions have these elements.

I have been following Townsend's terminology by referring to these as futures contracts. It would have been helpful had Townsend explained in greater detail the distinction between forward and futures contracts—a distinction crucial for understanding the role of an organized market, as I have argued in several articles. A forward contract is between two specific parties and may not be bought or sold without the consent of the other party. For example, General Mills might buy wheat forward from Continental Grain. This forward contract will specify a large number of particulars including the specific type of wheat; when and where it will be delivered and by what means, say truck or rail; how payment will be made and on what terms; and so on. General Mills may not sell this contract to another party and thereby extinguish its obligation to fulfill the terms of its forward contract nor may Continental Grain buy a contract from a third party and thereby satisfy its commitment to General Mills. In addition, those who negotiate the terms of these forward contracts must be knowledgeable experts on the commodity. They must know the grades and qualities of the commodities they handle and they must know the needs of their employers or principals. We may summarize by asserting that a forward contract is not a fungible instrument.

In contrast, a futures contract is fungible. It is not a transaction between two specific individuals. The buyer and the seller do agree on the price and quantity. But this agreement establishes an obligation to the organized exchange in the form of the clearinghouse of the exchange. The buyer has an asset, which is the liability of the clearinghouse, whereas the seller of the futures contract has a liability, which is an asset of the clearinghouse. Either the buyer or the seller can extinguish this instrument with the clearinghouse by making the appropriate offsetting transaction. The buyer can sell the futures contract to anyone at a mutually agreeable price then prevailing on the floor of the exchange. The seller can close his commitment to the clearinghouse by finding a buyer with whom a mutually satisfactory trade can occur at the then prevailing price. Neither the original seller nor the original buyer needs to know anything about the subsequent transactions. As a consequence, a futures contract is a highly fungible instrument. A futures contract stands to a forward contract in the same sense that currency stands to a check. In a trasnaction settled by currency the creditworthiness of the buyer is not relevant. The seller need only be sure that the currency is genuine—not counterfeit. However, if payment is made by check then the seller requires some assurance that the check will not bounce.

The fungibility of the futures contract and the greater liquidity of this type of contract relative to a forward contract is not its only important distinguishing feature. It also enables the principals of the transactions to use agents who can carry out their instructions while knowing far less about the particular details of the principal's situation. Reconsider General Mills.

Say it wishes to sell wheat futures contracts. It can give instructions to its agents who will carry them out on the floor of the exchange in the form of price and quantity. The agent does not need to know anything about the kind of wheat that General Mills uses or needs. All the agent needs to know is the minimal acceptable prices and the quantities that General Mills wants to sell. The abstract nature of the futures contract not only adds to its fungibility but it also permits specialization and thereby a reduction of cost.

Townsend does not discuss the theory aimed at explaining certain important aspects of prices on organized exchanges. In such exchanges prices change from one transaction to the next. At each transaction there is a rapid auction occurring among the traders and as soon as there is mutual agreement on price and quantity between a buyer and a seller, this price becomes public knowledge. But then what information can be gleaned from the prices because they change from one transaction to the next? Would it be better to have a few fixings per day as in the London gold market? Some of the relevant theories for studying these questions refer to the efficient market hypothesis. It might have been desirable to allocate some space to these questions and reduce the space taken up with the search models. The relevance of the search models to futures markets is not clear except for one fairly obvious point.

An organized market constitutes a single place where traders can meet and do their business. It is not necessary for them to wander aimlessly about some region looking for each other. Indeed, over a wide range of operation an organized market obtains economies of scale. The traders know where to go not only to reduce their search costs but also to increase liquidity—that is, individuals can have confidence of finding a ready market when they wish to transact and know that the prices will not reflect the effects of individual transactions. In this way the trades in the market itself gives a close approximation to the theoretical ideal of a perfectly competitive market.

Townsend's argument—that moving from random search among the traders dispersed in space to a focal point, an organized market, where all may meet and trade makes some traders better off and others worse off—is obscure. There is no coercion. A trader need not go to an organized market to make his trades if this would make him worse off than his available alternatives. Therefore there is surely a presumption of gains at least to all of the direct participants in the organized market.

The choice of a single place to have the market poses no difficulties. Unlike the simplified model of sophomore economics, in the world people can discuss how to arrange their affairs and design markets to satisfy their desires, which causes no loss owing to collusive manipulations. Here I disagree with Adam Smith. It is false and misleading to assert that whenever businessmen come together to discuss arrangements for setting up an organized market that the public will suffer. It is misleading to call organized exchanges natural monopolies. A single market is the most efficient—that is, the least costly—way of handling the transactions the businessmen wish to make. There is no loss of efficiency that accompanies a monopoly. On the contrary, the loss of efficiency would occur if erroneous notions of competition were to prevent the concentration of trade in a given commodity into a single place. Because the prices arrived at in an organized market convey information to everyone, including outsiders who do not trade in these markets, there is a free rider program. The exchange, its members, devise rules to protect themselves and help ensure their survival. Among these are rules to prevent members from making trades off the floor.

At several places in his paper, Townsend alludes to problems that he seems to believe require outside intervention. These problems are often merely casual remarks that do not reflect the same degree of care and thoughtfulness that he shows on almost every page. The question of how well government bureaucrats can regulate the exchange is a serious one that requires thoughtful consideration. It is an injustice to well-meaning regulators to toss off the instances where problems arise as casual asides. The exchanges themselves, especially the older ones that have encountered a wide variety of problems during their lifetimes (more than 130 years in the case of the Chicago Board of Trade), make up rules and police their members. This is not to say that the rules are never broken and that all violations are detected and punished. Yet it is true that self-regulation has the undoubted advantages that those who stand to lose the most for infractions have the greatest incentive to punish them. No one has devised a comparable system that gives third parties the same incentive of reward and punishment as presently exists in the organized exchanges.

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