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EQUILIBRIUM WITHOUT AN AUCTIONEER

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The development of the micro foundation of macro has been slow going; very interesting, but slow going. I want to begin with an elaboration of why this subject is hard (for me). I will then discuss two lines of research which explore what happens when economies are modeled without a Walrasian auctioneer -- search theory (Sec. I) and the theory of bank runs (Sec. II). This is, of course only one piece of the literature that identifies itself as the micro foundations of macro. I will concentrate on the flavor of results rather than the technical problems of constructing tractable macroorientated models within the micro rules of model construction.

The Fundamental Theorem of Welfare Economics makes possible straightforward use of the competitive general equilibrium model for the analysis of distortions in the economy. Since the economy would be Pareto optimal otherwise, it is easy to see the welfare implications of altering one of the assumptions of the Arrow-Debreu model. Observing pollution, one changes the assumption that production decisions do not affect individual utilities directly. One can then analyze the utility implications of pollution (compared with a different production technology or a different production decision), calculate socially optimal production decisions (for

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different criteria and different accompanying income redistribution tools), and design price and tax policies to improve or optimize resource allocation. A parallel literature analyzes congestion.

Observing sales taxes, income taxes, tariffs, and import quotas, one contrasts equilibrium with these government actions with that arising from some different level (perhaps zero) of these government set variables. In these examples, the relationship is clear between some easily observed phenomenon and the assumptions underlying the Fundamental Welfare Theorem. Naturally, economists differ on the quantitative importance of these deviations, which depend on the value of nontraded interactions and demand and supply elasticities.

Changing a second assumption of the Fundamental Welfare Theorem can alter the welfare analysis of a previous assumption change. One example is the Coase Theorem, where costless direct negotiations imply that pollution and congestion do not interfere with the Pareto optimality of equilibrium. Another example is optimal tax theory where the absence of lump sum redistribution of income, allows the equity gains from distorting taxes to outweigh their efficiency losses. In both cases, it is reasonably clear what observations are sufficient to select the appropriate theory to apply to a particular case.

This introduction on the standard style of microeconomic analysis is meant to highlight the ways in which the microfoundations of macro are different. There is the obvious difference with some micro analyses that macro attempts to address phenomena that are economy wide (or nearly so) rather than phenomena which occur in a single industry or group of industries or whose important effects can be analyzed in the context of a single industry, even though similar phenomena occur in many industries.
My focus here is on a separate difference. Macro starts with data on outcomes of the allocation process, data on unemployment, output, and capacity utilization, not with data on the assumptions of the Arrow-Debreu Model. It is not clear which of the many inaccurate assumptions of the Walrasian model are important for macro phenomena. The key word here is important, for all models are false. The choice of assumptions to change is important since welfare implications may vary over the sets of changed assumptions that give similar aggregate data.

Focusing on real variables, as I shall, not price levels, there are the basic stylized facts of macro. These can be divided into three categories. There are static facts of equilibria with low levels of output and factor usage. There are dynamic facts of the tendency of the economy to have prolonged movements up and down over time with fairly distinct turning points. And there are individual longitudinal facts on the pattern of unemployment. A satisfactory theory would address all three categories. However, the important factors explaining how the economy can have a prolonged period of low output may be different from the factors which are important for determining turning points. In turn, these two categories are conceptually separable from the individual incidence pattern of unemployment. Thus, it may entail enormous complexity to address all the stylized facts at one time. These observations do suggest that there is something wrong in the Arrow-Debreu model, but they do not point to any particular single assumption as the one that should be changed. And that is what makes macroeconomics so hard for microeconomists. Judgement on choice of assumptions is as important as analysis of particular assumptions. Moreover, it is likely that the behavior of the economy
depends in important ways on many of the deviations from the assumptions of the Fundamental Welfare Theorem, and not just on one or two.

Paralleling the usual microeconomic strategy, the micro foundations of macro proceed by altering just one or two assumptions of the Walrasian model. Such a small change can be made in the belief that a satisfactory model can be built with only a few changes. This I take to be the basic stance of equilibrium business cycle analysis, with missing markets and limited information, as the critical changed assumptions. Or one can believe, as I do, that it will be necessary to alter many of the assumptions of the Walrasian model, and yet choose to begin by altering just one or two assumptions rather than building a more radically new model. I consider a single leap to a totally different model to be too unlikely to succeed to consider pursuing.

When envisioning a research strategy that involves exploring many assumption changes, a researcher faces the problems of deciding which step to take next and of evaluating how well the project is going. Evaluation involves an even more selective use of empirical facts than usual, since an adaptation of the theory in its present state to fit some fact best approached in a later variant of the model can worsen the development of the project. For example, it may be better research strategy to pursue aggregate demand issues in a model without involuntary unemployment rather than complicating the model with the many reasons which combine to yield this phenomenon. I certainly hope so.

Walrasian theory is based on three premises: rationality, large numbers, and trade coordination by the auctioneer. The standard premise of rationality, including a correct understanding of the economic environment, is obviously not a universal trait. Individual behavior different from the
standard model, particularly in the forms of poor predictions and of wage and price stickiness, are probably central elements in the actual behavior of the economy. Similarly, many industries are dominated by small numbers of firms or unions, making price taking not a universal trait.

With both of these assumptions (rationality and large numbers), I think the US economy is significantly different from standard assumptions. In this symposium, however, I will focus on the third assumption - coordination by the Walrasian auctioneer. Other sessions are considering wage contracts and price setting games. Moreover it does not seem likely to me that the deviations from these two assumptions will be sufficient for a satisfactory macro theory. If it is going to be necessary to model differently the coordination of trade, the most rapid progress may follow from doing this analysis in a familiar setting of large numbers of conventionally rational agents.

Walrasian auctioneer

The Walrasian model assumes a very special trade coordination mechanism, in sharp contrast with the generality allowed in preferences and production technology. In other words, from the perspective of issues of trade coordination, the Arrow-Debreu model is a very special example, not a general model. The Walrasian auctioneer makes everyone aware of prices and trading opportunities in the economy at no cost to anyone. By coordinating would-be-traders (including selecting particular points in offer correspondences) the auctioneer makes trivial the problem of pairwise matching of buyers and sellers. Moreover, by coordinating all trade simultaneously the auctioneer gives each trader a single budget constraint. It is obvious that life is not like this. It takes time to learn about particular trading opportunities for goods, for labor, and for credit.
(Depending on one's feelings about shopping, this may be unpleasant or, up to some limit, pleasant). It is not easy to form a judgement about the stochastic properties of the attempt to trade, especially since the economic environment is not stationary. Moreover each individual trade must be completed with some form of purchasing power -- barter, money, or credit. Because of the sequential nature of trade, one only learns of one's (ex post) budget constraint over time.

Paralleling traditional micro analysis, we have identified the assumption of the Walrasian model we wish to change. The logical next step is to construct an alternative model to see if it fits data on resource allocation better than the Walrasian model, and to see if it has significantly different implications for important policy actions. The trouble is that the modelling problem is hard. Generalizing the trade coordination mechanism in interesting ways has, thus far, required severe restrictions on preferences and production technologies. In addition, the generalizations of trade coordination have been extremely narrow and unrealistic. As narrow and unrealistic as these mechanisms have been, most trade coordination technologies that have been analyzed include the Walrasian auctioneer as a special case when the coordination process becomes infinitely rapid. These models are therefore more general than the Arrow-Debreu model in this dimension while being less general in preferences and production technologies.

To proceed, we need three new descriptions, along with the familiar preferences and production opportunities:

(i) how people learn about the distribution of trading opportunities;
(ii) how individual pairwise trades are organized, which involves both matching and bargaining; and

(iii) how budget constraints evolve.

In terms of (i), it is probably significant for the shape of business cycles that at least some people do not accurately perceive the (time-dependent) stochastic structure of trading opportunities. I suspect that excessive entry in very good times tends to lengthen both booms and recessions. Nevertheless, the current literature has focused on the rational expectations special case. This choice reflects (at least) three factors. One is the lack of well documented alternative hypotheses (combined with diverse views on the extent and importance of error). A second is the complication from evolving perceptions (as opposed to the fixed point argument needed for rational expectations). A third is the desire to understand the workings of non-Walrasian allocation mechanisms in a rational expectations setting so as to isolate the implications of the change in allocation mechanism. I will stay within the rational expectations framework in the discussion below and assume that in equilibrium people just know the stochastic structure of trading opportunities.

To see aspects of the two remaining issues ((ii) and (iii)), I will consider output search models without credit and then credit models without search. Both are models without an auctioneer. In the absence of a Walrasian auctioneer (even with the usual assumptions about commodities) an economy will have unrealized mutually advantageous trading opportunities. That is, costly trade coordination will naturally yield lower economic activity levels than would occur with costless coordination. In addition, the extent to which mutually advantageous opportunities are not realized
will have partly endogenous determinants and endogenous dynamics. This gives the potential of explaining why output is particularly low at some times and why it tends to fluctuate. This is the heart of this approach to the micro foundations of macro.

I will proceed by first summarizing the simplest barter-search model which brings out an example of this mechanism. Then I will ask whether money, pricing behavior, or credit are likely to change the results. This will be followed by a fresh start indicating how the lack of an auctioneer in credit markets yields macro problems even with all other markets Walrasian.

I. Search Models

In the Walrasian model, all contracting comes first. Production and the delivery of goods are then spread out in time. While some goods are contracted for before production, much of commodity production is for inventory, in the hope of a quick sale at a good price. (I ignore for present purposes the perhaps important time structure of production labor, wage payment, and sale of goods.) The ease and profitability of trade from inventory depends on the level of demand, with the dependence varying with the specification of the trade coordination mechanism. Consider a barter economy with a single good which individuals produce but must trade before they can consume. Artificially keeping all traders in symmetric positions, we get one-for-one trade. With no money or credit, the level of demand depends on the distribution of stocks of inventories of others that are available for trade, as well (in more general models) as expectations about future production and trade opportunities. The greater the stocks of inventories of others, the greater the expected profitability of producing for inventory. Thus there is a trading externality which has a similar
character to technological (not pecuniary) externalities in the Arrow-Debreu model. Moreover this externality involves a positive feedback that greater inventories make production for inventory more profitable. Whether set up as a single period model or a stochastic stationary state, the equilibrium in such an economy (with a plausible trading technology) is marked by two features — inefficiency of equilibrium due to trading externalities and possible multiple equilibria due to the positive feedback. Both features come from the feedback mechanism that greater production for inventory makes production for inventory more profitable.

Prices are set in bilateral trade. With a symmetric structure, prices have no reason to respond to overall low output. Since I have discussed this structure at length in previous (now published) lectures, I do not want to use much of my limited time today spelling out such a model. Rather, I move on to the questions raised by this result: the three R's of realism, relevance and robustness.

**Realism.** When considered in the context of prolonged periods of low output, such as the 30's, it really is the case that production is more profitable when output levels are high, although simultaneity problems would make testing difficult. (Around turning points there probably isn't a static monotone profitability-output relationship.) That is, I think the model is capturing a real phenomenon. However there are many factors that lead to this high profitability of which the model captures only one, and not necessarily the most important one. There are distributional effects from the payment of wages before goods are sold; at a time of high output there is likely to be the old-fashioned accelerator effect; there may be reasons coming from long term contracts. No doubt there are others. Moreover there are alternative ways of modeling the economy which will give
a similar mathematical result (See Cooper and John.) -- e.g., monopolistic competition and suitable demand functions, especially with only approximately optimal pricing.

Since further model development depends on the interpretation given to the mathematical structure, one needs to choose the form of interpretation most likely to be helpful as well as a mathematical structure yielding the type of results one believes (or has checked) to be empirically correct. I don't think one could claim that this model captures an overwhelming fraction of the reasons that production is more profitable over a period when others are producing at a high level. The most that can reasonably be hoped is that this mechanism is an adequate surrogate for these other features which would require additional modelling complexity because of the need for more detail. In other words, perhaps this is a model which can be built on. It certainly is a model which is firmly in the microeconomic tradition.

Relevance. The purpose of the microfoundations of macro is to help with macro policy. Conventionally, macro policy means open market operations or cyclically sensitive tax or expenditure policies. In addition, macropolicy may include institutional reform. The class of models described so far do not have an adequate representation of either money or bonds to permit direct analysis of monetary policy. The most that can be gleaned from such models is the relevance of aggregate demand analysis for welfare economics and so the possibility of a consistent micro-based model for counter-cyclical monetary policy. Of course a useful monetary policy must affect aggregate demand--but all that this requires is that the policy not be equivalent to a change in monetary units, which is clearly the case for the full range of conventional monetary policy tools.
A similar conclusion can be reached for fiscal policy. The inadequacy of the model in this case arises from the complication of addressing lag structures, which are the most serious limitation for fiscal policies. The lack of institutional detail of the models makes them unlikely candidates for analysis of institutional reform. We are left with is a partial legitimation of conventional aggregate demand based approaches to macro policy in the face of the rational expectations attack, plus the hope of further model development.

Another sense of relevance is whether the model captures enough of macro problems to be relevant for macro. In particular, with the labor market clearing, can a too low level of output be a satisfactory proxy for a low level of employment? It is surely relevant for the shape of business fluctuations that low levels of aggregate demand result in high levels of (conventionally measured) unemployment rather than low wages or work-sharing. This set of micro phenomena, partially explored in the contracts literature, belongs in an eventual micro-foundations-of-macro model. It is surely relevant for actual macro policy. However, there is no reason to think it undercuts the (limited) policy inferences which come from the models under discussion. One would expect that replacing a perfect labor market by a more complicated imperfect allocation mechanism would enhance the welfare relevance of aggregate demand policy despite the possible presence of "offsetting effects". Moreover similar models can be built focusing on search in the labor market with perfect output markets. (See, e.g., Howitt and McAfee).

A third sense of relevance is whether the model is about important or unimportant effects. In the U.S., wholesale and retail trade value added is about 15% of GNP. This is a much larger figure than would occur with
a costless allocation mechanism. The problem of trade coordination is not trivial.

Robustness. The simplest models have limited pricing policies and credit markets. Is it possible that the conclusions of the simplest search models will be removed by the functioning of price or interest rate determination? After all, the simplest Keynesian model ignores prices; yet the role of prices is precisely to clear markets. I think this case is different. Implicit in a search model is decentralized (non-auctioneer) price determination. This can come about by bargaining or (with suitable institutional structure) prices set on a take-it-or-leave-it basis. In both pricing situations a fall in aggregate demand may well have the effect of lowering prices in a monetary model. (That the effect may be absent in a barter model is not relevant.) Is there reason to believe however, that such a mechanism will keep the economy on an even keel in the presence of either a tendency to endogenous fluctuations or macro shocks? (The fact that a pricing overreaction to monetary policy reverses the map of what is expansionary and what contractionary does not contradict the possibility of successful policy.) Such a conclusion seems unlikely. The simplest monetary version of the barter-search model described above has similar properties to the barter version. More fully fleshed out models seem to me very likely to preserve the twin features of generally inefficient equilibrium and possible multiple equilibria. The determinants of trading prices in a search setting offer little reason to expect price determination to approximate market clearing levels or offset inappropriate aggregate demand levels. This is not the place to catalog the reasons why some trading prices are not at competitive levels in search models. But I find the arguments persuasive.
Multiple Equilibria

The presence of multiple equilibria is a sign of an incomplete theory. Yet it is a commonplace in the micro foundations literature to take multiple equilibria as a virtue. A cursory literature search turned up no defense of this view, so I want to indicate why I share it. There is a mathematical basis for this view and an economic one. The mathematical basis is that static or steady state models with multiple equilibria often have dynamic versions with stationary or stochastic (sunspot) cycles. (Diamond-Fudenberg, Grandmont, Woodford) This seems to fit with the persistence of movements in modern economies. While I think it is important to understand a wide range of the mathematical properties of the models one uses I suspect that the expectation coordination mechanism of these rational expectations cycles is a small part of the range of causes of persistent movements and probably not an adequate surrogate for missing factors requiring a rich sectoral structure to model adequately. This basis of cycles focuses attention on educating the public to choose the right equilibrium, focuses on credibility issues, rather than pushing towards more realistic analyses of what is, in fact, a very complicated decentralized allocation mechanism. While expectations about the general stability of the economy matter greatly, we need to know much more about the effects of monetary and fiscal policy on individual transactions.

The economic basis for the view that multiple equilibria may be a virtue comes from a suspicion of how a richer class of models may work. For tractability, we generally work with static or stationary models. These are meant to approximate some portion of a richer nonstationary intertemporal model. In terms of the static view of some year in the 30's, it is natural to think that there was a high employment equilibrium
which might have been reached as well as the low employment equilibrium which was. The intertemporal links which select the particular equilibrium from the set of static equilibria are missing in the static model. Having a static model with multiple equilibria is consistent with the perspective that something led the economy to a poor outcome when it might have been led to a good one with a relatively small change in some actions (private or governmental). Another way of saying more or less the same thing is that monetary and fiscal policies seem to affect the real economy more than a Walrasian model suggests they should. The concept of pump priming is based on the idea of a large long-lasting response to a small temporary policy. In a complete model with a unique equilibrium, a large sensitivity of equilibrium to macro policy may come from the same factors that give an incomplete model multiple equilibria. The self-reinforcing nature of different expectations in a model considering only rational expectations may make induced expectation change a powerful lever in an expectation formation model.

Finance Constraint

Before proceeding to a discussion of credit, it seems useful to recast the discussion above in terms of budgets. Whether set up in a single period or as a steady state, the model described above has purchasing power determined by previous production decisions. In a search setting the level and distribution of purchasing power are then relevant for the level of trade in the economy, however trading prices are determined. I believe that one could greatly complicate the description of goods and preferences without altering the basic results of the model. The interesting direction of development however is the determination of purchasing power—does the
underlying problem of too little purchasing power change with the introduction of money or credit in the economy?

For simplicity, assume that goods are bought only with money (no barter or credit). The level of trade will depend on the level of inventories on the supply side and the level and distribution of real money holdings on the demand side. Nominal money holdings are determined by past actions. Real money holdings depend on nominal money holdings and price setting behavior. In a search setting, prices are set to optimize or are bargained over. There is no mechanism to assure an efficient level of aggregate demand although it is not necessarily too low. There is also no assurance of an efficient level of production for inventories. There are rampant externalities. Monetary policy in the form of a helicopter drop will alter equilibrium by altering the distribution of real money holdings unless the helicopter drop is precisely proportional to existing holdings.

With money and no credit, aggregate demand depends on past behavior determining the distribution of money holdings and current pricing behavior; production decisions are irrelevant. To bring back the relevance of production decisions for demand, we could add collateralized borrowing of money at a zero interest rate (for tractability). Although such a model has not been worked out, it seems likely that the availability of such credit makes production for inventory more attractive both privately and socially. This is in contrast to a production-unrelated line of credit available to everyone which merely adds to the stock of purchasing power and is neutral in steady state.

Production with inputs owned by others directly affects the distribution of purchasing power. Another link between current production and purchasing power is through possibly changed expectations about future
trading in the economy, and so a change in credit made available in the expectation of repayment from future trading. This suggests that credit availability is highly relevant for the workings of the economy and leaves open the role of interest rates as smoother or amplifier of macro difficulties.

II. Credit Models

When the resource allocation process is costly and/or time consuming, intermediation becomes relevant for the workings of the allocation process. In contrast to frictionless allocation models, models with friction do not give rise to Modigliani-Miller style irrelevance theorems. Moreover the credit allocation process itself has the potential of adding to the ways (arising from frictions in the goods and labor markets) in which the economy is sensitive to short run aggregate demand.

Credit allocation takes resources and time. Costly evaluation of credit worthiness is sufficient for the existence of financial intermediation, provided the rest of the institutional structure is appropriate (large projects calling for pooling or economies of scale in small credit transactions plus adequate monitoring of the intermediary). For some modelling purposes however it matters that the allocation process takes place in real time rather than having all transactions take place at one time. Here is where the absence of an auctioneer matters.

I start with all-at-once trading. Consider a Fisherian two period economy. Each person is endowed with a production possibility set defined over output-today and output-tomorrow. With a Walrasian coordination mechanism we have each person choosing a production and consumption pair both of which lie on the same budget line, tangent to the production possibility set and an indifference curve. Projects with particularly
large investments (relative to the endowment of the owner of the production possibility) will involve negative levels of output—today as part of the production possibility plan. Since negative consumption is not possible, borrowing is necessary to carry out such a plan. In this sense, the availability of credit enlarges individual production possibility sets as well as permitting a more efficient aggregate production plan.

Alter this story by replacing the Walrasian auctioneer by some other mechanism which involves either transactions costs or some degree of market power for some agents and, in general, we have a different final allocation. With either different underlying production possibilities or changes in the credit allocation mechanism, the difference between the allocation and the Walrasian allocation can vary. That is, a shock to the production technology can widen the gap between Walrasian and non-Walrasian outcomes. Or, a shock to the credit allocation mechanism can have a similar widening effect (Bernanke and Gertler). Bernanke has previously argued that the difficulties of banks in the 30’s resulted in a lower level of production through such a mechanism. It is particularly the sunk cost of information gathering about individual debtors that makes the system sensitive to the intermediation structure. Having banks in trouble affects the production plans of the economy.

In a repeating discrete time model of this type, banks will get into trouble if they make bad investments. This can happen because of corrupt bank management, or poor selection of investments, or calculated gambles that come out badly. The latter may arise from interest rate changes in a richer model than a single pair of periods and certainty.

Once we recognize that the allocation process takes place over time and that many transactions are financed by money holdings, there is the
opportunity for intermediaries to borrow by providing liquidity services. That is, there is a niche in the set of intermediaries for one that makes purchasing power available on demand or very short notice and on terms involving little risk. This possibility naturally depends on a suitable transactions cost structure plus the uncertain evolution of purchasing power needs of individuals.

Given the existence of such intermediaries, the fact that the allocation process is spread out in time implies the possibility of bank runs. This has been modeled by Diamond and Dybvig as multiple equilibria in a discrete time model with bank action restricted to limited observation of what is happening in a period. This artificial restriction in a discrete time model is a natural way to capture aspects of a more realistic continuous time model. The critical ingredient here is that the value of an asset portfolio depends on the speed with which it must be sold. This can arise from the cost of evaluation of individual assets (rather than waiting for them to mature), the difficulty of quickly finding eager buyers for idiosyncratic assets, and the market power of hard to find eager buyers. Such problems can arise for individual banks. They can also arise for entire banking systems. The implied drop in perceived wealth is relevant for aggregate demand.

In contrast to the Diamond-Dybvig approach of modelling bank runs as one of (at least) two equilibria, Chari and Jagannathan and Postlewaite and Vives have constructed models where there is a unique equilibrium with some states of nature in which there is as a bank run, with accompanying inefficiencies.

The flavor of these results can be brought out in a continuous time Poisson model. Consider an individual with wealth $W$ at time zero. There
are two available investments. The illiquid investment opportunity yields a random return \( r \) (with mean \( \bar{r} \)) at time one. If this investment is undertaken, consumption occurs at time one and utility is equal to wealth consumed (i.e., risk neutrality). Thus expected utility from this investment strategy is \( W(1+\bar{r}) \). Alternatively, the wealth can be held in liquid form giving zero financial return. During time from zero to one however, there is a flow probability that a "good" consumption opportunity will arrive. If one arrives, it costs precisely \( W \) and yields utility \( W(1+b) \). The opportunity is only available fleetingly, so that someone without liquid wealth cannot take advantage of it. In addition, whether a consumption opportunity is ordinary or "good" is not observable to others. (This will be recognized as a variant of Goldman preferences. For consideration of the Diamond-Dybvig model with more general preferences, see Jacklin.) If no opportunity arrives by time one, the wealth \( W \) is consumed. Thus, expected utility for someone holding the liquid investment is \( W(F(1+b)+(1-F)) = W(1+Fb) \), where \( F \) is the probability of the arrival of a consumption opportunity before time one.

Let us assume that the underlying technology is such that the liquid investment strategy is optimal for an isolated individual. Then we have

\[
\bar{r} < Fb
\]

(1)

We will add other conditions as we go along.

Now assume we have two individuals with identical and independent consumption opportunities and perfectly correlated illiquid investment opportunities. Because of the independence of their abilities to profitably use resources early, there is a pooling opportunity. Together, they can hold 0, 1 or 2 times \( W \) in liquid form. With full information, total expected utilities for these levels of liquid holdings are then
2W(1+\overline{r}), \ W(2+\overline{r}+(2F-F^2)b), \ 2W(1+Fb)

We assume that the aggregate mixed portfolio is optimal:

\[ F^2b < \overline{r} < bF \]  

(2)

We have repeated (1) as well as giving the new condition. Thus pooling has the potential of raising expected utilities.

We now consider the difficulties of implementing this strategy under various information and observation technologies. We have assumed that the arrival of a good consumption opportunity is not observable. Remember that such an opportunity is only fleetingly available at some time in the continuous interval between zero and one. The natural symmetric rules are that the first of the pair to try to withdraw the liquid wealth \( W \) may do so. The other depositor then receives the illiquid investment at time one. If neither withdraw, they share equally the total wealth available at time one. By our Poisson assumption they don't both attempt to withdraw at the same time. If each one only attempts to withdraw when there is a genuine consumption opportunity, expected utility for each of them is half the total return from this social strategy with full information. From the assumptions in (2), this is a perfect Nash equilibrium.

There are a variety of ways of creating difficulty for this equilibrium. Following Diamond and Dybvig we can simply consider the situation if each one begins to think that the other might withdraw funds shortly whether or not an opportunity arrives. This consideration occurs after funds have been committed to the investments. (It would be more realistic to consider a continuous overlapping generations model.) Rushing down to withdraw before the other attempts to yields \( W(1+fb) \), assuming that none of the probability of consumption opportunity has passed. If the other person withdraws first expected utility is \( W(1+\overline{r}) \). Thus we have a
classic prisoners' dilemma where there are two Pareto comparable Nash equilibria once funds have been committed. The story can be enriched by adding depositors and adding assets which can be sold off at a loss. This lowers further the return to late withdrawals in the event of a bank run and reinforces the conditions that give rise to the prisoners' dilemma situation. Diamond and Dybvig argue that deposit insurance has the potential to ease this difficulty.

Following Chari and Jagannathan and Postlewaite and Vives one can now add signals to the model. These arrive early in time and (for mathematical convenience) not simultaneously to both depositors. Signals could contain information about the random return on the illiquid asset or the arrival rule of consumption opportunities. For some signals, immediate attempted withdrawal is the unique Nash equilibrium response. Examples are signals of a sufficiently low illiquid return or sufficiently high probability of either your own "good" consumption opportunity or of the other person's. For low probability signals, this can occur as part of a perfect equilibrium with the bank behavior described above.

The indivisibilities assumed in this example severely limit the set of interesting contracts. An overlapping generations model (without observability of age) would also limit contracts. Bounded rationality and transactions cost also limit contracts. So I do not find this limitation telling against the model.

A cornerstone of these models is a limited technology available to banks (as well as an allocation process spread out in time). The existing literature has taken the degree of liquidity in the investment technology as given. Even with this limited perspective on the scope for intervention, deposit insurance is potentially useful to prevent harmful
scrambles for liquidity. But this form of modelling misses the additional role for a central bank associated with open market operations. Since liquidity comes primarily from borrowing and from the sale of assets to others, rather than from early realization of physical investments, the menu of liquidity-return tradeoffs is endogenous. By acting at the macro level on the available tradeoff as well as on the micro level on run behavior, a central bank can seriously affect resource allocation. However, the problem of modelling the endogenous determination of the liquidity technology is a major one on which I have seen no work.

While bank runs are the most visible phenomenon involving multiple equilibria of this sort, I believe similar phenomena occur elsewhere in the credit allocation process. Wherever there are multiple creditors and an expectation of credit rollover, there is a similar situation. Willingness to lend depends on beliefs about both the borrower's and the lender's abilities to borrow in the future. I believe that this can yield multiple equilibria in credit extension without the special circumstance of demand deposits or intermediation of any kind. That is, the positive feedback of beliefs about easy credit or the easy availability of credit has the potential of generating both easy credit and tight credit equilibria. This possibility parallels the work of Pagano that a stock market can have thin and thick equilibria (i.e., equilibria with few and many traders) because of the dependence of volatility on the thickness of the market.

Credit and Search

Output-search models give multiple equilibria and inefficiency. Credit-intermediation models have similar properties. This naturally raises the question of interactions. The credit market may well amplify fluctuations from the goods market as credit availability depends on
perceptions of future output levels. This raises the natural question of whether interest rate variations won't offset this feedback and (returning to the theme of robustness) possibly alter the findings of the simplest model. The interest rate affects the likelihood of failure to repay a loan by requiring a different future payment (as well as having adverse selection and moral hazard implications which are familiar from the credit literature). This limited ability of interest rates to clear the credit market is a fundamental difference between static and intertemporal trade.

Concluding Remarks

In a Walrasian system, the evolution of aggregate demand (either endogenously or in response to shocks) is of no consequence for efficiency. In a search mediated economy (as in one with existing incomplete lagged contracts) the evolution of aggregate demand matters. This raises three questions—how aggregate demand affects the static efficiency of the economy, how government policies can affect aggregate demand, and how systematic manipulation of aggregate demand affects the evolution of the economy. To pursue these questions, we need a richer set of tractable models of allocation processes that are more realistic than the Walrasian auctioneer. Staying within the micro rules of model construction, it has been hard to construct even special models (much less general models) encompassing the set of institutions needed to answer these questions. Nevertheless the existing models point up the likelihood that macropolicy can be used constructively and make the case that this is a potentially very valuable research agenda, as well as one which is fun.
References


