



POLICY DISCUSSION PAPERS

Recent Developments in Monetary  
Economics: A Summary of the 2004  
Workshop on Money, Banking, and Payments

by Ed Nosal, Guillaume Rocheteau, and Randall Wright

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# Recent Developments in Monetary Economics: A Summary of the 2004 Workshop on Money, Banking, and Payments

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We provide a summary and an overview of the papers presented at the Federal Reserve Bank of Cleveland's 2004 Workshop on Money, Banking, and Payments, held during the weeks of August 3-7 and August 23-27, 2004. The papers presented at the workshop are available at [www.clevelandfed.org/research/confpast.cfm](http://www.clevelandfed.org/research/confpast.cfm).

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## Introduction

The summer of 2004 provided another occasion for the Federal Reserve Bank of Cleveland to host a workshop on monetary economics, broadly defined to include theoretical and quantitative work on money and monetary policy, as well as research on banking, payment systems, and related issues. Twenty-six papers were presented over the course of two weeks. Below we summarize some key contributions of the presentations and try to tie them together whenever appropriate. Although classifying the papers by topic is somewhat arbitrary, we arrange the summaries under the following headings: Foundations of Monetary Theory; Money and Other Assets; Pricing; and Money, Banking, and Payments.

The papers are on diverse topics and use a variety of theoretical and quantitative methods. Nevertheless, there is a very consistent theme, which is the following. Monetary economics should use logically coherent models and avoid “shortcuts” like simply assuming money gives agents direct utility, or that purchases are simply subject to an unmodeled cash-in-advance constraint. These papers try to explain at a relatively rigorous level the reason that money is used in the first place, as well as the interaction between money and other assets or other institutions like banks. These papers also try to take seriously the microeconomics of price formation. While most of this work is theoretical and often fairly technical, it typically has interesting and often novel implications for policy. Indeed, a unifying view seems to be that in order to understand and implement monetary policy in a satisfactory way, it is essential to have models that strive to take microfoundations theory seriously.

## Foundations of Monetary Theory

There has been rapid progress in monetary theory with rigorous microfoundations in recent years. In terms of models that are very tractable and still allow us to address many practical policy concerns, such as the cost of inflation, for example, there are currently two main popular frameworks—the Shi model with large families or households, and the Lagos-Wright model with centralized and decentralized markets and quasilinear preferences. Both of these models are tractable because they deliver a degenerate distribution of money holdings across agents in equilibrium—that is, they admit a representative agent. Although this is not the only interesting case, it is a nice benchmark because it is relatively simple to analyze. Many papers at the conference worked on extending or applying these models. Other papers stepped back and worked with more primitive models that are less obviously directly related to policy but that help us understand the theory and issues at a deeper level.

Miquel Faig proposes a framework that encompasses the Shi and Lagos-Wright models in “Divisible Money in an Economy with Villages.” His approach avoids some problems of the household model, where members may have different interests from those of the family, and it can accommodate more general preferences than Lagos and Wright can. In Faig’s model, agents can trade both “within villages”—that is, with people with whom they interact frequently, where they can use bonds and insurance contracts—and “across villages”—that is, with relative strangers, where they need money. His model generates similar predictions to those of Lagos-Wright regarding the intensive margin effects of inflation and the welfare cost of inflation, and similar results to those of Shi regarding the extensive margin effects of inflation. This helps reconcile some ostensibly conflicting results in recent monetary policy discussions.

In “Money Creation in a Random Matching Model,” Alexei Deviatov considers a setup with indivisible money, where monetary policy and the trading mechanism in each match are chosen optimally, subject to the requirement that the outcome in each match is in the pairwise core. Using numerical examples, Deviatov contrasts his results with those of Molico (see below), who assumes a given bargaining protocol (buyer-take-all). Using different notions of Pareto optimality, he shows that whenever expansionary monetary policy is optimal, the trading mechanism does not correspond to this bargaining protocol. This helps us to understand, or at least raises the issue of, whether some recent results in monetary policy research are robust or whether they are sensitive to details concerning the assumptions.

In “Core Allocations in Matching Models,” Tao Zhu pursues a deep approach to monetary theory in a way that is closely related to Deviatov’s work. Zhu asks: In economic environments where money is essential, what kinds of restrictions on allocations should we impose on our theories? This is not the typical approach, as many modelers instead make some assumptions about, say, how agents bargain, and then derive equilibrium. He suggests the following natural restrictions: Basically, agents agree to participate in the exchange process, they have no incentive to deviate from the outcome, and the outcome does not prescribe that pairs of agents end up doing something that is not the best they could do relative to bilateral deviations. He then uses this approach to discuss several models in the literature from a new perspective. The key innovation over much work in game theory is that he imposes the condition that allocations must be immune to bilateral as well as unilateral deviations. This is a good first step in understanding more about what our theories should assume.

Robert Reed and Chris Waller, in “Money and Risk Sharing,” consider a variation of the Lagos-Wright framework, where money is interpreted as an insurance mechanism. The “night” market is a competitive environment, where agents produce for money. In the “day” market, agents are endowed with output that is subject to both idiosyncratic and aggregate risk. The idiosyncratic risk is that an agent’s endowment will be either positive or zero, and the aggregate risk is that the positive endowment is either high or low. If agents knew in advance their endowment, they would bring into the day market exactly the amount of cash required for consumption. Given that the endowment process is uncertain, agents will readjust their money balances at “night.” Reed and Waller show that the Friedman rule is optimal in the sense that agents will always bring in sufficient real balances to purchase first-best consumption—hence, money provides perfect insurance. When policy deviates from the Friedman rule, agents bring in inefficiently low levels of real balances. The authors calibrate the model and find that the welfare cost of going from 10 percent inflation to zero is worth around 1.5 percent of consumption, lower than the estimates of some other papers at the conference, but still higher than those of papers that do not model the microfoundations of money explicitly.

In “Compensation for Quality Difference in a Search Model of Money,” Balázs Szentes and Yuk-fai Fong consider an environment in which the role of money is to compensate agents in bilateral matches for differences in the quality of the output they produce. There are no asymmetries of information, but agents choose the quality of their output. Agents want to consume once per period and can engage in two rounds of meetings. When fiat money is not valued, there is no equilibrium where all agents produce high-quality goods, but there is an equilibrium where all agents produce low-quality goods. The intuition for why an equilibrium does not exist in which all agents produce high-quality goods is that if everybody were to produce high quality, each agent would have an incentive to defect from

proposed play by producing low quality because he could still, in this model, trade for high quality with probability one. When money is valued, there is an equilibrium where almost all agents produce high quality. The presence of fiat money gives incentives to produce high-quality goods because producers can be compensated for their production cost by receiving cash as well as goods.

In “Search Intensity versus Shopping Frequency” by Xiuhua Xuangfu, agents have two choices: how often to shop (enter the trading process), and, when they do, how much effort to devote to shopping. Standard models of money have only examined these dimensions or margins separately. The two margins will be affected by a change in inflation. A novel prediction of Xuangfu’s model is that the effect of a change in inflation on the frequency and intensity of shopping depends upon the level of inflation. In particular, in low-inflation environments, an increase in inflation results in high search intensity but has no effect on frequency. When inflation is high, a change in inflation affects only the participation decision. These results help us to understand better how monetary outcomes influence the frequency of trade and hence output.

Steven Russell’s “Random-Matching Money Demand in an Overlapping Generations Model” is an ambitious attempt to compare and hopefully integrate the currently dominant paradigm of the monetary theory literature, which is based on search theory, with the previously dominant program, which is based on overlapping generations models. While the environment he studies is somewhat special, he is able to produce a coherent model, which combines interesting features of both approaches. The predictions of his model are novel. This work improves our knowledge of both theoretical approaches and helps us to understand robust features of monetary economics more generally.

### Money and Other Assets

Monetary economics faces (at least) two important and related challenges: One, to explain why agents use money instead of IOUs (credit arrangements); and two, to explain the coexistence of money and interest-bearing assets. While the first challenge has been met successfully by recent models, the second is still an open issue. Several papers at the conference pursued this topic.

Neil Wallace, in “Another Nonrobustness Result for the Cash-In-Advance Equilibrium in the Trading-Post Model,” argues that so-called trading-post models, which try to explain the coexistence of money and government bonds that pay interest, do not successfully address this challenge. Trading-post models are based on the notion that goods are traded in localized markets where only two different goods can be exchanged. These models typically exhibit multiple equilibria, since a trading post can be inactive due to self-fulfilling expectations. There are some refinements in the literature to deal with this multiplicity. Wallace shows that a proposed equilibrium in which money is one of the two goods that is traded at each active post—that is, where money is the universal medium of exchange—is not robust to refinement: Agents will defect from proposed equilibrium play (using money as the money of exchange) and will instead use interest-bearing government bonds.

In “Money and Credit in Organized Trade,” Peter Howitt also discusses trading-post models as a way to account for the rate-of-return dominance puzzle, which is: Why do agents sometimes use an asset that has a lower rate of return than another asset? He assumes that while it is costless to redeem

matured government bonds for money, it is costly to exchange unmatured bonds for money. Howitt shows that an equilibrium exists where agents use money as a universal medium of exchange; that is, money trades for goods, but bonds never trade for goods. While other equilibria may exist in which agents use bonds as a medium of exchange, and such equilibria may dominate in terms of welfare the equilibrium where money is used, Howitt argues that social convention may ultimately dictate which equilibrium we settle into, and the economy may settle into an equilibrium that is inefficient.

In “Liquidity, Interest Rates, and Output,” Shouyong Shi proposes an integration of two macroeconomic models: his household model of monetary exchange, and Lucas’s model with limited participation. Households hold a portfolio of government bonds and money. Bonds are sold by the government in a competitive market for cash. The amount of bonds sold each period is subject to random shocks. Since buyers in the bond market cannot read just their money balances, these shocks generate liquidity effects. In contrast to the original model by Lucas, Shi relaxes the cash-in-advance constraint and lets bonds compete with money as a medium of exchange. The coexistence of the two assets is achieved by introducing a legal restriction that prohibits bonds from being used in all the trades where money can be used. Interestingly, the endogenous nominal interest depends on agents’ preferences as well as the frictions in markets and legal restrictions. Also, Shi shows how independent shocks can lead to autocorrelation in interest rates.

In “Efficient Monetary Allocations and the Illiquidity of Bonds,” Paola Boel and Gabriele Camera consider an otherwise standard model of money with heterogeneous agents. Heterogeneity has two dimensions: Agents have different discount factors, and agents receive idiosyncratic shocks to preferences. The Friedman rule will not implement the first-best outcome since the economy will only be able to deflate to the rate of time preference of the most patient agents. Hence, in any monetary equilibrium, impatient agents will hold inefficiently low levels of monetary balances. To this environment, illiquid government bonds are introduced. This improves matters, and the reason is similar to that in recent work by Kocherlakota—illiquid bonds allow liquidity to be allocated to agents who need it, from those agents who have it. In some circumstances, it may be possible to implement the first-best allocation.

In addition to studying the coexistence of money and bonds, several papers addressed the coexistence of money and capital. In “Money and Capital,” Borağan Aruoba, Christopher Waller, and Randall Wright study one such model, where capital is fixed in place and cannot be transported to decentralized markets, and because agents are anonymous in these markets, money is essential. As in Lagos-Wright, because of quasilinear preferences, the distribution of money and capital is degenerate. If capital does not affect agents’ productivity in the decentralized sector, the model has a dichotomy: Variables in the decentralized sector, such as real balances, are determined independent of variables in the centralized sector, such as capital. Thus a change in monetary policy does not affect capital accumulation. If, however, capital does affect productivity in the decentralized sector, the dichotomy no longer holds and monetary policy affects the centralized sector. They also show that if decentralized prices are determined by bargaining, monetary equilibria are always inefficient, while if the decentralized market is Walrasian, the Friedman rule gives efficiency.

In “Money and Capital as Competing Media of Exchange,” Ricardo Lagos and Guillaume Rocheteau describe an environment where, in contrast to Aruoba, Waller, and Wright, fiat money and capital goods can compete as means of payments. They ask whether money and capital can coexist,

and whether money is still essential. As in the standard Lagos-Wright model, trades alternate in centralized and decentralized markets. In the absence of money, the equilibrium is efficient if the capital stock that a social planner would choose is large enough to allow agents to implement the first-best trades in the decentralized market. If the socially efficient level of capital is too low, in this sense, agents tend to overaccumulate capital to use it as a medium of exchange. The authors show that a monetary equilibrium exists whenever the nonmonetary equilibrium is socially inefficient. The presence of fiat money allows agents to reduce their capital stock and to trade more in bilateral matches. The key result is to show the circumstances in which fiat money may still be essential even if capital can be used as a medium of exchange.

In “Monetary Policy and the Distribution of Money and Capital,” Miguel Molico also studies a model with monetary exchange and capital accumulation. Agents are able to store only their own consumption good, which implies that capital cannot be used as a medium of exchange, and they have access to a competitive market where they can reallocate their portfolios. In contrast to the previous two papers, in Molico’s model, all production takes place in decentralized markets, and the distribution of agents’ wealth is nondegenerate. This requires the use of relatively high-powered computational methods. Molico shows numerically that the distribution of money balances is relatively flat compared to the distribution of capital. Another interesting finding is that the poorest agents in the economy tend to hold a larger fraction of their wealth in cash. This approach constitutes a very serious attempt to study monetary economics in situations where the distribution of money and capital matters.

Pierre-Olivier Weill, in “Leaning against the Wind,” presents a simple model where market makers provide liquidity by buying and selling assets. The assumption is that market makers have continuous access to the market but investors trade only infrequently. It is shown that the efficient allocation, which can be implemented as a decentralized equilibrium, is characterized by the price of the asset moving discontinuously following a negative shock, and by market makers’ intervention sometimes being delayed—that is, they do not necessarily start buying assets immediately after the shock. Hence, what might be perceived as a lack of liquidity in financial markets following a negative shock may, in fact, be an efficient outcome.

In “Search Frictions and Asset Pricing,” B. Ravikumar presents an extension of the Lucas asset pricing model, where assets are liquid in the sense that they can be used as means of payments in decentralized markets with bilateral meetings. This offers a nice integration of standard asset pricing models and monetary models. The novelty in comparison to Lucas’s model is that asset prices incorporate a liquidity component. The novelty compared to monetary models is that the good that is used as a medium of exchange is a real asset, not fiat currency. He shows that the model has the potential to explain some long-standing macroeconomic puzzles related to the equity premium and excess volatility.

In “A Model of (the Threat of) Counterfeiting,” Ed Nosal and Neil Wallace build a simple model of money with the potential for counterfeiting. In contrast to the existing literature, counterfeiting, if it occurred, would be accompanied by two distortions: costly production of counterfeits and harmful effects on trade. It is shown, however, that when counterfeits are not durable, there is no equilibrium with counterfeiting. If either the cost of producing counterfeits or the probability of detecting a counterfeit is low enough, then there will be no monetary equilibrium. Otherwise, there is a monetary equilibrium without

counterfeiting. This certainly will make economists think hard about what we need to build a robust theory of counterfeiting.

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## Pricing

Many monetary economists are interested in optimal policy and the welfare costs of inflation. In many models in modern monetary theory, bargaining theory is used to determine the terms of trade. Several papers at the conference explore the details of bargaining, or some alternative pricing mechanisms.

In “Bargaining and Exchange,” Guillaume Rocheteau and Christopher Waller ask if the precise details of the bargaining process have implications for policy. They consider several bargaining solutions that are alternatives to the usual one in the literature, the generalized Nash solution. The alternative solutions are ones that have been proposed in the game theory literature but never applied in macroeconomics. The authors find that the welfare costs of inflation for the various bargaining solutions are similar when one considers decreasing inflation from 10 percent to zero, and these costs are considerably larger than the costs predicted by more traditional models with price taking instead of bargaining. However, when one considers the benefit associated with decreasing inflation from more moderate levels, say 4 percent to zero, the predictions depend more sensitively on the bargaining solution. This work is important for understanding how the details of our theories matter for their predictions and implications for policy.

In a related paper, “Search, Money, and Inflation,” Huberto Ennis considers models of money in which the terms of trade are determined by bargaining when the seller has all the bargaining power. In the benchmark model in the literature, monetary equilibrium will not exist under this specification because the seller will extract all of the gains from trade, and so the buyer will have no incentive to acquire money in the first place. Ennis’s paper explores the implications of introducing asymmetric information and heterogeneity among the buyers. Heterogeneity, by itself, is not enough to generate a monetary equilibrium. Ennis’s model has two forms of heterogeneity: *ex ante* and *ex post*. The *ex post* heterogeneity, which is whether or not the buyer has a high valuation for the good, is private information. The paper solves the problem in an elegant and tractable way. Interestingly, the welfare costs of inflation are of similar magnitude to those generated in papers that use bargaining. This model will be a new benchmark, which is, in many ways, more interesting and more realistic than some earlier papers in this literature.

In “Sticky Prices,” Ben Craig and Guillaume Rocheteau investigate the welfare effects of inflation in a monetary economy in which there are fixed costs to adjusting prices. They first analyze a version of the model where there is no transaction demand for money balances. They show that the optimal inflation rate can be positive because of a congestion externality in the goods market. They then extend the model to incorporate an essential role for money. If prices can be adjusted at no cost, the Friedman rule is optimal. In the presence of menu costs, price stability corresponds to a local minimum in terms of welfare—that is, some inflation is better than price stability. However, and this is a key new result, the optimal monetary policy corresponds to a negative inflation rate. Nevertheless, the optimal policy is not necessarily the Friedman rule.

In “Inflation and Incomplete Price Adjustment,” Alan Head considers a model of monetary exchange with large households, where the distribution of money holdings is degenerate. He assumes



that sellers have the ability to post prices which, in most standard monetary models, is incompatible with the existence of monetary equilibrium. However, in contrast to previous models, buyers here may be able to sample more than one price, and therefore they can be more or less informed about prices in the economy. This heterogeneity of buyers' information generates an endogenous distribution of prices. The model can be used to study the effects of monetary and real shocks on the distribution of prices. For example, longstanding notions about higher inflation being correlated with more price dispersion can now be subjected to rigorous analysis.

In "Indivisibilities and Lotteries under Incomplete Information," Luis Araujo and Andrei Shevchenko consider an economy where agents are bilaterally matched and there is incomplete information about the quantity and value of money. Through decentralized market interactions, however, agents are able to make inferences about the true value of money. Since agents can have different private experiences in the market, price dispersion may arise (as in Head's model). Their economy may have multiple equilibria, where in one equilibrium the economy is characterized by price dispersion and in another it is characterized by one price. When multiple equilibria exist, it may be the case that the price-dispersion equilibrium yields higher welfare than the one-price equilibrium. The intuition behind this result is that the existence of price dispersion provides agents with more information about the underlying structure of the economy compared to the single-price equilibrium, and this information is valuable for decision making.

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### Money, Banking, and Payments

Institutions such as banks both compete with and are complementary to money in terms of providing a means of payment. Several papers discuss banking and the interaction with money and monetary policy.

In "Divisible Money and Banking," Ping He, Lixin Huang, and Randall Wright extend their previous work, which shows how to integrate interesting and historically accurate accounts of banking into the search-theoretic monetary literature. That work made some strong assumptions (like indivisible money) for the sake of simplicity and for the sake of comparison with the early search-and-money models. The current project relaxes these assumptions. They generate novel predictions about what monetary policies are feasible and optimal. The paper is an important next step in understanding payments systems generally—especially because it provides a fairly rigorous microeconomic foundation for competing means of payment, such as cash and checks.

Ricardo Cavalcanti's "Money with Bank Networks" considers a model of two inside monies, each of which is issued by banks belonging to a different network. The motivation is to explain the following observation: At the beginning of the nineteenth century, many banks competed against one another, and bank notes were a major item on their balance sheets, while by the end of the century, there was consolidation (fewer banks) and bank notes were no longer so prominent (being replaced by credit). In Cavalcanti's paper, banks decide whether to join one of two networks. The benefit of joining a larger network is that a bank will be able to issue a larger number of notes; the cost is that a bank will have to redeem more liabilities. Cavalcanti considers equilibria where, in one network, members redeem not only their own liabilities but also those of the other network, and in another network, members redeem only their own liabilities. He shows that when the size of the banking sector is small relative to the size of the

economy, both networks may coexist, and much of the trade in the economy is mediated by notes. When the banking sector becomes larger, however, the only stable equilibrium has a single network, and credit is responsible for mediating a large portion of trade in the economy. This provides a coherent theory of this interesting historical observation.

Aleksander Berentsen, Gabrielle Camera, and Christopher Waller consider an economy where agents receive idiosyncratic preference shocks that affect their desire to consume in “Money, Credit, and Banking.” If the monetary policy corresponds to the Friedman rule, agents can perfectly insure themselves against these shocks. Since preference shocks occur after agents have made their choice of real balances, there is a need to reallocate liquidity from agents with a low marginal utility of consumption to agents with a high marginal utility of consumption. It is shown that banks can fill this role by collecting deposits and making loans. Assuming an enforcement technology that guarantees loans are always repaid, an equilibrium with banks exists, and banks improve welfare as long as we are not at the Friedman rule. In contrast, if there is no enforcement technology, equilibrium with banks may not exist close to the Friedman rule. A government policy of contingent taxes and transfers is unable to replicate the banking equilibrium. The authors also investigate how the presence of banks mitigates or exacerbates different shocks.

David Mills’s “Alternative Central Bank Credit Policies for Liquidity Provision in a Model of Payments” is a variation of a standard model of payments extended to allow the possibility of default on interday credit. Mills examines two payments mechanisms that are designed to prevent default. These examples come from actual systems that we observe. Although the paper does not set out to characterize the optimal payments mechanism, one of the mechanisms that is studied can, at times, implement the first-best allocation. The two mechanisms that are examined are one, costly enforcement and cost recovery; and two, collateral. From an efficiency point of view, collateral is undesirable because, when the opportunity cost of collateral is positive, consumption decisions are distorted. The costly enforcement mechanism with cost recovery does not distort consumption because economic agents pay a fixed cost for enforcement after any investment decisions are made. The particular mechanism that is best will depend upon the relative costs of running each system in a way that is made clear. All of this constitutes progress in understanding banking and payments systems, and the implications for policy.

**Papers Presented at the Summer Workshops on Money, Banking, and Payments**

Session I: August 2-6, 2004  
 Session II: August 23-27, 2004

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| Peter Howitt  | II             |
| <b>Search Frictions and Asset Pricing</b>   |                |
| B. Ravikumar  | I              |
| <b>A Model of (the Threat of) Counterfeiting</b>  |                |
| Ed Nosal and Neil Wallace   | I              |

**Papers Presented at the Summer Workshops on Money, Banking, and Payments (cont.)**

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