Is Why We Use Money Important?

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MONEY PLAYS A CENTRAL ROLE IN DETERMINING THE COURSE OF MACROECONOMIC ACTIVITY. PRICES AND INFLATION ARE DIRECTLY LINKED TO THE NATION'S MONEY SUPPLY, AND MANY ECONOMISTS BELIEVE THAT CHANGES IN THE QUANTITY OF MONEY ALSO HAVE IMPORTANT EFFECTS ON REAL ECONOMIC VARIABLES, SUCH AS UNEMPLOYMENT AND gross domestic product, especially in the short run. Yet many of the models that economists use to evaluate fundamental questions relating money and monetary policy to economic activity tend to gloss over the underlying characteristics of the economy that motivate the use of money. Economic models that simply assume currency is valued overlook these characteristics and possibly the important properties of money that influence the way its supply affects the economy. Understanding these properties will provide a better idea of not only the key features of money that associate it with "value" but also how those characteristics affect the link between the quantity of money and aggregate economic activity.

Economists define money by its functions as a medium of exchange, a store of value, and a unit of account. Its function as a medium of exchange is unique.[1] Money serves as an alternative to interest-bearing assets because it is the easiest asset to exchange directly for goods and services; that is, it provides liquidity services. Macroeconomic models often assume exogenously that money is used in carrying out transactions. One approach is simply to specify a money-demand relationship that says the demand for currency depends positively on income and negatively on the nominal interest rate (a relationship that empirical money-demand studies have confirmed). Another widely used approach is to capture the notion of money demand within the context of neoclassical economic models. Such models base macroeconomic outcomes on the microeconomic decisions of households and firms in perfectly competitive markets. These approaches typically motivate the use of money in transactions in one of two ways. Cash-in-advance models impose a constraint that says current expenditures must be financed with previously accumulated holdings of cash. Money-in-the-utility-function models treat money as a special asset that yields satisfaction, or utility, to the holder. The idea behind this approach is that money's liquidity services, not money itself, provide utility to individuals.

At first glance, it seems very reasonable to simply assume that money is used to buy goods and services. After all, this assumption is true in virtually all modern economies. Yet it presents some fundamental problems, especially within the context of neoclassical macroeconomic models. The hallmark of neoclassical economics is the idea that markets are perfectly competitive and that no difficulty exists in trading goods for goods. Goods and services are exchanged in a centralized marketplace, and an auctioneer coordinates trades and ensures that they occur at market-clearing prices. In such a framework, there is no need for a medium of

exchange and no role for money. Simply assuming a cash-in-advance constraint or that the liquidity services of money provide utility is thus inconsistent with the underlying economic environment of the neoclassical model. In order to explain why individuals use money, there must be frictions in the transactions process that make trade difficult.

These trade frictions that underlie the value of money may be crucial in addressing two types of fundamental questions in macroeconomics. The first type deals with how monetary policy affects economic activity: What effect do changes in the growth rate of the money supply have on productive activity? What are the consequences of inflation on economic welfare? Economic models that ignore the trade frictions that explain money's usefulness inevitably overlook how changes in economic policies affect those frictions. For example, monetary policies may be used to reduce trade frictions by making exchange easier and encouraging buyer and seller participation in the market. This effect would be overlooked in economic models that do not account for the frictions that cause money to be used in the first place.

A challenge to monetary economics is to construct models that explicitly capture the transactions role of money and can be used to address central issues in monetary economics and macroeconomics.

The second set of questions deals with the choice and use of alternative currencies in transactions: In particular, why would different (international) currencies circulate within a particular country, and why might a group of countries adopt a common currency? It is not possible even to address such questions in economic models that assume at the outset that a particular currency is used. The challenge to monetary economics is to confront these fundamental problems by constructing models that explicitly capture the transactions role of money and can be used to address central issues in monetary economics and macroeconomics.

A promising class of models that responds to this challenge is the search-theoretic approach to money. At the heart of this approach is the idea that because transactions take place at different places and times, meetings between buyers and sellers are not instantaneous. Individuals must spend time or resources to search for sellers who have goods they would like to consume and who are willing to trade them for something the buyer possesses. In such an environment barter is costly because of the difficulty of finding a "double coincidence of wants." That is, for barter to take place, not only must the buyer want the good the seller has, but that seller must also want the good the buyer has. A universally acceptable medium of exchange, which may be intrinsically useless fiat money, is valued because it overcomes the double-coincidence-of-wants problem associated with barter, thus making trading easier. This function of money is certainly not new; it dates back to the earliest writings of classical economists more than a century ago (Jevons 1875; Wicksell 1911). Yet until recently it had not been well formalized using the tools of economic theory.

This article will first explain how search and matching models of money identify the characteristic assumptions for motivating the use of money in carrying out transactions.[2] The pioneering work in this area by Kiyotaki and Wright (1989, 1991, 1993) was driven by some fundamental questions in monetary economics: Under what conditions will objects emerge that circulate as mediums of exchange? Which objects, including commodities, would circulate, and how important are their intrinsic properties and the extrinsic beliefs regarding their acceptability? How precisely does the use of money as a medium of exchange affect liquidity and welfare?

While the search-theoretic approach seems well-suited for studying such abstract and intellectual questions in monetary theory, one wonders how such a model can be useful to modern economies. This article uses two approaches to argue that search models of money do indeed shed light on some important issues in modern macroeconomics that may have empirical relevance. First, because search models make internal, rather than ex ante, assumptions about which currencies emerge as mediums of exchange, such models are uniquely qualified to study questions that arise naturally in international monetary economics. For example, what determines which currencies are used in a particular country, and what are the costs and benefits to a country of having its currency circulate internationally? These questions are relevant to "dollarization" issues or, more generally, currency substitution. Second, an explicit treatment of the transaction role for money may have significant implications for the economic impact of monetary policy and inflation. For example, an increase in the money-supply growth rate and inflation can provide an incentive for buyers and sellers to participate more actively in the market. In turn, a higher degree of market participation can affect the ease

of finding trading partners, hence reducing the severity of trade frictions in the marketplace. This additional channel by which monetary expansions can affect economic activity may be important in stable-price, low-inflation countries. It also provides an alternative to the Keynesian sticky wage and price literature, which finds a positive link between money, inflation, and output.

This article summarizes some of the recent literature on search models of money and their successful application to these issues. The article is not intended to provide a comprehensive review of the search-money literature. Instead, it highlights representative contributions that demonstrate the applicability of search models to monetary and macroeconomic theory and suggests directions for future work.

When considering search-theoretic approaches to money, one should keep in mind that economic theory inevitably involves a high degree of abstraction, especially in macroeconomic models based on microeconomic behavior. The models economists use are vast simplifications of the real world. This stylized world helps isolate and analyze the relationship between a few important variables of interest. The assumptions these models make and the way they capture interactions between economic participants are necessarily approximations that will not accurately represent all aspects of the actual macroeconomy. Yet economic models can be extremely useful in two related respects. First, they provide a logically consistent framework for analyzing the interrelationships between important economic variables. Second, if the outcomes of the models capture important features observed in reality, then these models can have predictive power.

What Is a Search Model of Money?

Search-theoretic models focus precisely on the various frictions motivating the use of money as a medium of exchange. These frictions are characterized by the following properties: (1) a separation of market participants: there is no centralized marketplace, and all trades do not occur at the same place at the same time; (2) differentiated goods: there are many different types of goods and many individuals with different tastes; and (3) anonymous trading with no public "legacy:" trades occur anonymously in that the trading histories of each individual are not public information.

The first two properties lead to a double coincidence problem with barter. Ms. Burger Queen, who makes hamburgers but likes pizzas, must find Mr. Pizza Delight, who makes pizzas and likes hamburgers. This search takes time because many other individuals in the economy produce and consume different types of goods. For example, as Ms. Burger Queen searches for an opportunity to trade her hamburgers for pizzas, she might encounter Mr. Pizza Express, who makes pizzas but needs a haircut. Since there is no double coincidence of wants, only a single coincidence, trade will not take place. This simplistic story illustrates that locating a barter exchange is a time- and resource-consuming process that makes trade complicated without a medium of exchange.

The third property, anonymous trading, permits money to act as an objective record keeper of past actions and enables otherwise impossible transactions. For example, suppose that Ms. Burger Queen, who makes burgers and likes pizzas, meets Mr. Pizza Express, who needs a haircut. Ms. Burger Queen may request that Mr. Pizza Express give up a pizza (in exchange for nothing, since she does not know how to give a haircut) because she previously gave up a hamburger to another individual for nothing and would like compensation for her good deed or because in the future she promises to respond in kind to another individual. If everyone were willing to follow through on his or her promise to respond in kind then this "credit arrangement," involving giving up goods in exchange for nothing but a promise that others will respond in kind, would be the most efficient means of exchange. However, if Ms. Burger Queen's trading history is not public information or there were no way to enforce her commitment to respond in kind in the future—that is, if trade is anonymous—then Mr. Pizza Express would have no incentive to enter into this arrangement.

In anonymous trading, when people trade with others they do not know, they are not willing to engage in any exchange that is not quid pro quo. A medium of exchange substitutes for an abstract promise to respond in kind and hence acts as a record keeper in a world with anonymous trading. Search models capture anonymous trading by

1. Because a medium of exchange must be held during the time after income is received and before it is used to purchase goods and services, it is also a store of value. Stores of value, such as interest-bearing financial assets, do not necessarily serve as mediums of exchange, however.
2. Search models are sometimes called matching models because of the way buyers and sellers meet or "match" with each other in the market.

assuming individuals are matched with each other randomly and one-to-one for the purpose of trade. These models of money show explicitly how these three properties lead to the use of money as a medium of exchange.

A Prototype Search Model of Fiat Money. Kiyotaki and Wright (1991, 1993) formalize the way acceptability ultimately drives the use of fiat money as the medium of exchange in an economy with the type of trade frictions described above. The intrinsic properties of commodity monies, such as gold or silver objects, may make them more acceptable than others. Yet acceptability lies at the heart of a social choice of a medium of exchange without intrinsic value. Consequently, both of these seminal studies focus on fiat rather than commodity money.[3] To demonstrate these concepts, this article outlines the important elements of a prototypical search model of money and discusses its findings. The assumptions of the model are very simplistic and will not accurately reflect various aspects of real economies. The model is designed to illustrate how intrinsically useless fiat money can become an acceptable medium of exchange, that is, the model investigates the circumstances that determine when fiat money will be valued as an equilibrium outcome. Furthermore, the logic behind the model's main ideas will also hold in more complex economic environments that come closer to reality.

Imagine an economy with many different types of goods and individuals. Individuals have different tastes and therefore would like to consume only a small fraction of the total goods. Call this fraction x. For example, there could be three types of goods and three types of people in the economy: fruit lovers who like only fruit, vegetarians who consume only vegetables, and carnivores who like only meat. If each individual likes only one-third of the overall goods produced in the economy, $x = 1/3$. Hence, x is a measure of the overall acceptability of goods in the economy. Individuals specialize in the production of a particular type of good and look for opportunities to trade for the goods they would like to consume. In this example, a vegetable producer may like to eat only fruits. Also assume that individuals are able to produce and carry only one unit of a good at a time as they search for opportunities to trade. Thus, if an exchange does occur, it will be a one-for-one swap of goods for goods. Finally, individuals value their time and would prefer to consume sooner rather than later.

The model is dynamic in that it considers the behavior of these individuals over time. At the beginning of the "day," each individual produces one unit of her good (her "production good") and enters the market to search for opportunities to trade her good for one she likes to consume (her "consumption good"). For trade to occur, each individual must find someone with a double coincidence of wants. Recall that x is the fraction of all goods in the economy that each individual finds desirable. As each person (randomly) meets others in the market, the chance that she will like the good another individual is carrying will be x, and the chance that another individual likes her good will also be x. Thus, the probability of a double coincidence of wants for each meeting is $(x)(x) = x^2$. If x is small, say 1/3, then the probability of a double coincidence of wants will be much smaller, $x^2 = (1/3)(1/3) = 1/9$. This comparison is what makes barter difficult in the model. Every time an individual meets a potential trading partner, there is only x^2 of a chance that the individuals will actually be able to trade for the goods they want to consume. It takes time to find that double coincidence of wants, and individuals value time. In this barter economy, once a double coincidence of wants is found, trade occurs, the individual enjoys consumption, she produces another good, and the process begins again.

Next consider the introduction of fiat money into this economy—say, pieces of paper that have no intrinsic value. To keep everything simple, assume that individuals can each hold at most one unit of money or one unit of a good that they produce themselves (but not both). These units of money (dollars) are also indivisible (that is, they cannot be divided into quarters, dimes, and so on). Let M denote the fraction of the population holding money and $(1 - M)$ the fraction holding goods. Since individuals are either holding one unit of money or none, M also corresponds to the total money supply. Additionally, these assumptions imply that an exchange is simply a one-for-one swap of goods for goods or goods for money. Each individual believes that if she holds money, the chances that a seller will accept that money for her production good is Π. If $\Pi = 1$ then she believes that all individuals are willing to accept money for her good, if $\Pi = 0$ then she believes no one will accept money for her good, and if $0 < \Pi < 1$ she believes money may be accepted sometimes. Thus, Π represents the economywide acceptability of money.

Suppose an individual begins the day with a good that he has produced himself and proceeds to the market to look for trading opportunities. The chance that he will encounter another individual also holding a good is now $(1 - M)$, the fraction of the population holding goods. But, as before, he will be able to barter only if there is a double coincidence of wants, and the chances of that happen-

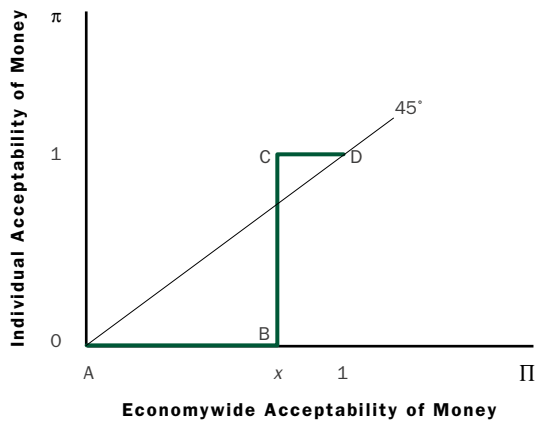
ing may be very small (x^2). On the other hand, the probability that he will encounter individuals holding money is given by M. The chance that these individuals would like to buy his production good with money is given by x. When this happens, he as the seller must decide whether or not he is willing to surrender his production good for this intrinsically valueless piece of paper. This "willingness" is denoted as π. The possible choices for π are

$\pi = 1 \Rightarrow$ he always accepts the money;
$\pi = 0 \Rightarrow$ he never accepts the money.

The seller's choice will depend upon his belief in the "economywide willingness" of other people to accept money in exchange for their goods, defined earlier as Π. If another person likes the seller's goods and he is willing to accept money, he will trade his good for money. If this exchange happens, the seller now becomes a buyer with a unit of money and must search for an individual who has a particular good, an event with the probability $(1 - M)$. The chance that another individual has his consumption good is x, and the probability that the other individual is willing to accept money in exchange for that good is Π. If the buyer can exchange his unit of money for his consumption good, he consumes it and produces another unit of his production good, and then the process begins again.

The key question is, under what conditions would an individual be willing to surrender a production good for an intrinsically useless piece of fiat money, given the individual's beliefs about Π? The answer can be summarized by a simple diagram, illustrated in the chart. Along the horizontal axis is Π, which can be viewed as the independent variable since each individual takes his belief about the economywide acceptability of money as given when deciding whether to accept money. This decision to accept money is the dependent variable π, plotted along the vertical axis. The darker line connecting points A, B, C, and D shows the value of π that individuals who are acting in their own best interests should choose for a given Π. The individual choice of whether or not to accept money, π, will ultimately determine the economywide, or equilibrium, value of Π.[4] The 45 degree line indicates that because everyone behaves in a similar way, an equilibrium is a situation where $\pi = \Pi$.

Equilibrium in the Prototype Search Model of Money



Hence, an equilibrium in the model economy is a situation where the 45 degree line intersects with the line ABCD.

Suppose individuals believe that $\Pi = 0$; that is, no one else in the economy is willing to trade his or her goods for money. Giving up one's own good for money would then be foolish because the money would be essentially useless. Hence, the best decision is never to accept money and to choose $\pi = 0$ as well. In fact, as long as $\Pi < x$, so that money is less acceptable in exchange than goods, individuals should still choose $\pi = 0$ and never accept money. This outcome is shown as line AB along the Π-axis between 0 and x. Given $\Pi < x$, there is a *pure barter equilibrium*, in which no one accepts money in exchange for goods and $\pi = \Pi = 0$. This event is shown where line AB intersects with the 45 degree line at point A.

Now consider the other case where $\Pi = 1$. In this case, individuals believe that all others in the economy are always willing to give up their production goods in exchange for money. Consequently, each individual should be willing to do the same. Why? If someone does not trade her good for money, the chance that she will be able to barter with someone holding her consumption good is the double-coincidence probability of x^2. By accepting cash today, however, the chance that she will be able to trade that money for goods is merely the likelihood that she likes another's good, or x, which is greater

3. Kiyotaki and Wright (1989) use a search-theoretic model to study the properties of commodity monies that lead them to be used as mediums of exchange.
4. Economists call this equilibrium concept a Nash equilibrium from game theory. Everyone is pursuing the best strategy he or she can, given the actions of others. The situation is a symmetric Nash equilibrium if all individuals end up pursuing identical strategies.

than x^2. That is, because money is always acceptable to others, all that is needed is a single coincidence of wants to trade money for goods instead of a double coincidence of wants. If everyone else accepts money, then it will be in each person's best interest to do so as well and to set $\pi = 1$.

Following the same logic, as long as $\Pi > x$, money is more acceptable in exchange than goods, and individuals should still choose $\pi = 1$ and always accept money themselves. The line CD at $\pi = 1$ between x and 1 demonstrates this concept. Therefore, if $\Pi > x$, then there is a *pure monetary equilibrium*, in which everyone accepts money in exchange for goods and $\pi = \Pi = 1$. Graphically, this equilibrium is where the 45 degree line intersects line CD at point D. These results demonstrate that monetary exchange is a self-fulfilling prophecy. Money is accepted in exchange simply because of the belief that others will accept it as well.[5]

Because search models make internal, rather than ex ante, assumptions about which currencies emerge as mediums of exchange, such models are uniquely qualified to study questions that arise naturally in international monetary economics.

Kiyotaki and Wright next analyze how the use of money affects social welfare or the overall lifetime welfare of individuals participating in their model economy. They show that if finding a double coincidence of wants is very difficult—that is, if x is small enough—then the use of money is socially beneficial. It minimizes the search costs associated with exchange by providing liquidity. Increasing the money supply, M, however, does not always increase liquidity. Because money in this model is indivisible and individuals can hold at most only one unit, an increase in the money stock, M, necessarily increases the number of people holding money and reduces the number of people holding goods, $1 - M$. Thus, increasing the money stock "crowds out" goods. Hence, too much money may also make trading difficult by reducing the number of sellers with goods in the market ("too much money chasing too few goods"). This relationship can be seen in the quantity exchange equation, in which the velocity of money (V) is given by the ratio of nominal output to the number of dollars in circulation, or $V = PY/M$, where P is the price level and Y is real output. Since individuals can carry only a unit of cash or goods, total output is just the fraction of those individuals not holding money, or $Y = (1 - M)$. Furthermore, one-for-one exchanges of goods and money imply a nominal price of one ($P = 1$). Thus, $V = (1 - M)/M$. Increasing M will always reduce the velocity of money. This reduction is reenforced by the crowding out of goods. Eventually, increases in the money supply will inhibit liquidity if M is high enough.[6]

What about Prices? The prototypical search model of money outlined above provides a logically coherent theory of money as a medium of exchange. Yet it also relies on some very special assumptions. Among them is the notion that goods and money are indivisible and all exchanges are one-for-one swaps of goods and money. This notion necessarily implies that nominal prices are exogenously fixed and equal to one. It is only a first step in thinking about money as a medium of exchange. While the model captures the protocol of exchange, it says nothing about the determination of the prices at which exchanges occur.

A straightforward way around this difficulty, explored by Trejos and Wright (1993, 1995) and Shi (1995), is to incorporate *bilateral bargaining* as a mechanism to determine prices. The idea is to think of goods as exchangeable services that are divisible but not storable. Examples of these types of goods are haircuts and perishable fruit. Hence, when individuals meet, these goods must be produced and immediately traded. When a buyer and seller meet, they bargain over the price that divides the gains from trade between them in a particular way. A nominal price would simply be the ratio of the quantity of goods, q, exchanged for a unit of indivisible currency, $p = 1/q$. This price is affected by factors that influence an individual's bargaining power and opportunities to walk away from a trade. Such factors include the aggregate quantity of money and the ease of finding other trading partners. This model is the prototype search model of money with prices.

Under certain conditions, an increase in the money stock, M, can lead to lower prices if M is small and higher prices if M sufficiently large. If M is very low, then an increase in the money supply enhances market liquidity and the bargaining power of buyers. In order to implement the trade, sellers must reduce the asking price on their goods. Just as in the prototype model, however, high values of M can impede liquidity by reducing the quantity of goods available for trade. This reduction distributes bargaining power in favor of sellers, and prices rise with increases in the money stock. This (imperfect) link between the quantity of money and liquidity also has other real effects. For example, if M is low, the frequency of transactions, output, and welfare can increase with a higher money stock. The even-

tual "inflationary" effects of continuously increasing *M*, however, lead to a decline in these variables. Thus, the quantity of money can have important effects on output by influencing the relative difficulty of how buyers and sellers meet and the prices negotiated at those trades. Monetary policies should not overlook such liquidity effects when an "optimal quantity of money" is being formulated.

These results demonstrate that prototype search models of money make a significant contribution to the pure theory of money. By explicitly considering the frictions that make trade difficult, they demonstrate the necessary conditions that lead individuals to use money rationally as a medium of exchange. These models can also be used to study, in a stylized fashion, the links between the quantity of money, liquidity, and prices. Such approaches, however, are by no means limited to the pure theory of money. Next, this article discusses these models' usefulness in examining important monetary and macroeconomic issues.

International Currency

When a particular country's currency is also used for transactions in other countries, it is called an international currency. Issues involving international currency are at the forefront of today's economic headlines. For example, what are the long-term economic consequences of European countries' adopting the euro? Should Latin American countries abandon local currencies in favor of the dollar? One of the distinguishing features of search models of money is that they are designed to examine which currencies are used to carry out transactions. Traditional international models that simply assume the use of a particular currency have nothing to say about these issues. Search-theoretic approaches emphasize the endogenous determination of mediums of exchange and are naturally suited to study the use of dual and international currencies.

Matsuyama, Kiyotaki, and Matsui (1993) take the first step in applying search-theoretic models to study international currencies. They consider two countries, each of which issues its own currency. The populations of both countries are growing, and each government issues its money through purchasing goods from individuals—that is, money creation generates seigniorage revenue. Individuals are randomly matched for the purpose of trade, with two individuals from the same country meeting more frequently than individuals from different countries. Even with the assumption that exchanges are one-for-one swaps of goods and money and involve fixed nominal prices, Matsuyama, Kiyotaki, and Matsui are able to analyze such issues as how and when local currencies can survive in the presence of a universally accepted international currency and whether an international currency emerges naturally as economies become more integrated.

Generally, several types of outcomes are possible: there may be no international currencies, one country's currency may circulate in both countries, or both may circulate in both countries. The authors find that the degree of economic openness, as measured by how often buyers and sellers from each country interact, is central in determining which currencies are acceptable in trades. For example, if it is relatively easy for Mexican buyers to meet Mexican sellers but relatively hard for U.S. buyers to meet Mexican sellers, then pesos will not circulate in the United States. In addition, as long as the rate at which Mexican buyers meet U.S. sellers is not too low, dollars will circulate as the international currency in both countries. Such outcomes are possible if the supply of international currency is not too abundant and the noninternational currency is not too scarce.

Incorporating prices into the framework via bargaining allows the model to address a host of additional issues regarding purchasing power and exchange rates. How, for example, does the international circulation of a currency affect its purchasing power at home? How are policies designed to achieve higher levels of seigniorage or welfare affected by currency substitution? Trejos and Wright (1996, 2000) explore these issues. A variety of outcomes is possible, and conditions similar to those in Matsuyama, Kiyotaki, and Matsui (1993) must hold for one international currency to exist. In this case, Trejos and Wright they find that the international currency will have more purchasing power at home than abroad, and it will have more purchasing power in the foreign country than the noninternational currency.

This result also has an interesting implication for the observed empirical failure of purchasing power parity. Many empirical studies find that when prices are converted to a common currency, richer countries tend to have higher prices. While there are various explanations of this phenomena, none

5. There is an intermediate case in which $\Pi = x$. In this case, money and goods are equally acceptable in exchange, $\pi = \Pi = x$, and the equilibrium occurs where the 45 degree line intersects line BC.
6. In such a situation, although an individual seller can easily trade his or her good for money, economywide liquidity is inhibited since almost all individuals in the economy are buyers with money who cannot find sellers with goods.

explain why the United States is an exception to this regularity. That is, U.S. prices are much lower than predicted by cross-country income-price level regressions (Balassa 1964; Rogoff 1996). Search models offer a unique perspective on this issue. If the dollar is used in other countries as an international currency, the model predicts that its value in the United States should be higher, implying a lower domestic price level. Intuitively, acceptability and liquidity give money value in this model, and acceptability and liquidity abroad enhance its value at home.

This framework also provides some novel policy implications. For example, if both the domestic and a foreign currency circulate within a country, then maximizing seigniorage would require the domestic money supply to exceed its welfare-maximizing level. This requirement is so because dual currencies diminish the degree to which domestic currency is used, hence also diminishing the "inflation tax base." Increased coordination between the monetary policies of the two countries, however, may actually imply that increases in seigniorage and welfare are consistent with lower money supplies in both countries relative to noncooperation.

Search models have been extended to study other related issues regarding the use of multiple currencies. Zhou (1997) allows the possibility of currency exchanges in the model outlined above; Craig and Waller (1999) study the impact of currency reform and apply their framework to the recent effort of the Ukrainian government to remove the U.S. dollar from its economy and encourage the use of a new domestic currency; and Curtis and Waller (2000) consider illegal and black market currency exchanges.

Money, Inflation, and Economic Activity

One of the most prominent and debated issues in macroeconomics is the impact of the quantity and growth rate of money on inflation and economic activity. Earlier Keynesian macroeconomic models based on rigidities in prices and wages predicted a positive trade-off between inflation and productive activity. New classical models predict that while monetary policy can have important short-run effects, such as when changes in the money supply are unanticipated, inflation in the long run will be detrimental to economic activity. These new classical findings also hold in models that approximate the transactions role of money via a cash-in-advance constraint or placing money into the utility function. In these models, higher money growth creates inflation, taxing all activities involving cash. Individuals reduce their cash holdings, buy fewer goods and services, and overall economic activity declines. Yet all of these approaches simply assume an exogenous transactions role for money, overlooking the ways monetary policy and inflation can affect the very frictions that cause money to be used.

Short-Run and Long-Run Effects of Money. Traditional macroeconomic theory suggests that there are important differences between the short-run and long-run effects of monetary policy (Friedman 1968; Lucas 1973; Barro 1976). In particular, the common belief is that in the short run an increase in the money supply tends to expand output, while the long-run effect is primarily price inflation. Wallace (1997) investigates whether these results logically proceed from a matching model of money. His framework builds on the prototype search model of money with prices and considers the effect of a one-time increase in the stock of money, M. Since money is indivisible and individuals hold at most one unit, only those not holding cash may receive the cash transfer. The model incorporates a special assumption regarding what individuals know about the size of the increase in M. In the period in which M increases, or the short run, the public knows new currency has been distributed to a portion of the population, but does not know how much has been distributed. An individual who receives one unit of cash today does not learn how many others have also received cash. In the period following the short run, all individuals learn about the size of the increase. This period and all subsequent periods are called the long run.

Wallace finds that in the short run, increasing the money supply in the above manner leads to an increase in output with no impact on the price level. Intuitively, prices are already determined based upon the expected size of the increase in M. Since individuals do not know the actual size of this increase, it has no effect on current prices. The additional money in the economy enhances liquidity, which in turn increases the frequency of transactions and output. Once individuals discover the size of the increase in M in the long run, bargaining between buyers and sellers results in a higher price level much the same as in Trejos and Wright (1995). While the frequency of transactions is higher, the quantities exchanged are lower, leading to ambiguous effects on overall output. Thus, a search model of money replicates a macroeconomic feature of money most economists would agree with: while short-run changes in money have real effects, long-run changes have primarily nominal effects. The model also conforms with the view that information lags are important in explaining the real effects of unanticipated changes in monetary policy.

How Can Search Models of Money Study Inflation? The prototype search model of money

with prices provides a first step in understanding how such models can be used to study the interaction between money, prices, and economic activity. Their applicability is severely limited, however. Recall that these models assume money comes in indivisible units and cannot be divided. Since individuals can hold only one unit of money or a good, the quantity of money is directly linked to the proportions of the population holding either money, M, or goods, $(1 - M)$, and increasing the money supply necessarily crowds out goods. Furthermore, these assumptions make it impossible to analyze policies that change the growth rate of the money supply and the inflation rate.

Three approaches have been used in the literature to deal with these issues. First, and perhaps most straightforwardly, one could use the prototype model and approximate the effects of inflation by a tax on fiat money (Li 1994, 1995). However, since there are essentially no prices in the prototype search model of money (they are fixed at one) and the money stock is fixed, this approach only suggests how search frictions affect the interaction between inflation and welfare.

To capture the notion of money growth in a more realistic way, these search models must be able to account for the individual decision to demand and hold many units of currency at a given moment. The second approach uses this methodology by directly generalizing the prototype search model and allowing individuals to accumulate many units of cash (Molico 1999; Camera and Corbae 1999). A third approach is to have individuals choose divisible money holdings in an environment in which they are interacting with a very large number of buyers and sellers over the shopping period (Shi 1997, 1999; Laing, Li, and Wang 1999, 2000). Each of these approaches has its advantages and has proved useful in studying various aspects of the money supply and the inflation process. The following subsections will discuss each approach in more detail.

Inflation as a Tax on Money. In the prototype search model of money, one can draw some implications of inflation and welfare by thinking about the effects of taxing fiat money. Such a methodology allows one to retain the simplifying assumptions that goods and money are indivisible and exchanges are one-for-one swaps. Li (1994, 1995) pursues this methodology in two articles. First, these studies modify the model so that, instead of a completely random matching process, individuals can choose the frequency with which they contact others in the market. In such an environment, individuals tend to invest too little effort in search, and the frequency of transactions is too small to be socially beneficial. Individuals consider only their own private gains, rather than social gains, when deciding how much to search.

The studies then consider the effects of imposing a tax on money balances in a way that resembles an inflation tax. In this process, the government obtains seigniorage revenue by randomly confiscating money from money holders and using it to purchase goods from goods holders. The similarity between this taxation rate and actual inflation is that as a buyer shops with money, there is a chance that his money holdings will be confiscated and devalued (made worthless). The studies show that such a taxation process can increase the level of individual investment in search. Intuitively, if the chances of having one's money taxed increase, the incentives to find and exchange one's money for a desirable consumption good increase as well.

The intrinsic properties of commodity monies may make them more acceptable than others. Yet acceptability lies at the heart of a social choice of a medium of excchange without intrinsic value.

This relationship improves the overall rate of transactions and may lead to an improvement in economic welfare. Moreover, if individuals are able to accumulate inventories of goods, as in Li (1994), they may hedge against the inflation tax by increasing their inventory stocks. This result is analogous to individuals shifting holdings out of money and into nonmonetary assets when inflation is high. The findings suggest that a low but positive inflation tax may actually have beneficial effects by promoting inventory accumulation and the frequency of transactions. This measure, precluded by monetary models that ignore trade frictions, would tend to counter the costs of inflation identified in traditional macroeconomic models.

Inflation and the Dispersion of Prices. One well-known empirical regularity of inflation is that high rates of inflation are often associated with a greater dispersion of prices across goods in the economy; that is, high inflation causes the distribution of prices in the economy to widen.[7] This relationship is

7. For evidence from historical hyperinflations, such as those experienced in post–World War I Germany, see Graham (1930) and Hercowitz (1981). Van Hoomissen (1988) provides empirical support for the more recent inflation in Israel.

evident not only in the distribution of relative prices of different goods, such as apples and oranges, but also in the distribution of the price of similar or identical goods across different sellers. For example, Wal-Mart and Kmart may charge different prices for a similar television set, and the evidence indicates that higher overall inflation will likely increase the difference in these prices. These effects of increasing uncertainty about the prices of goods and distorting relative prices are important welfare costs of inflation. Clearly, macroeconomic models of money that assume all individuals are identical and participate in perfectly competitive markets have little to say about how inflation affects price dispersion.[8]

A search model of money replicates a macroeconomic feature of money most economists would agree with: while short-run changes in money have real effects, long-run changes have primarily nominal effects.

Molico (1999) extends the prototype model with prices by allowing individuals to accumulate and store divisible units of currency. Since individuals are randomly meeting each other and accumulating and spending money at different times, there will be a distribution of money holdings across individuals. Buyers and sellers again negotiate prices in a way that divides the gains from trade between them, depending on how much money the buyer has available to trade. For example, if a buyer with ten dollars meets a seller, the benefit the buyer gets from spending an extra dollar to purchase a good will be different from that of someone with only two dollars. Consequently, prices will generally be different in each trade, depending on buyers' money holdings, and there will be price dispersion.

The model verifies that changes in the growth rate of the money supply, and hence inflation, can have important redistributive effects on money holdings across the population. In particular, Molico finds that if the new money is distributed to individuals in a lump sum, an increase in the rate of monetary expansion would decrease the dispersion of prices and improve welfare if inflation is sufficiently low. In contrast, increasing money growth in a high-inflation environment would increase price dispersion and hence lower welfare. Thus, injecting the economy with new cash has two opposing effects. First, it reduces income inequality by making individuals with low money holdings relatively better off than cash-rich individuals, thus reducing price dispersion. Second, inflation lowers the average amount of real money held per person proportionally to an individual's money holdings, thus increasing inequality and price dispersion. If the inflation rate is high enough, this latter effect can dominate the former.

These results conform with empirical studies from hyperinflation countries. They suggest that countries with very stable prices and low inflation, such as the United States, the United Kingdom, and Japan, may actually benefit from money growth because it will narrow price dispersion and wealth inequality. But in countries with high inflation, such as Germany after World War I and Latin American countries in the 1980s, inflation will exacerbate the dispersion of prices, with detrimental effects on economic activity and welfare.

Inflation and Capital Accumulation. Beginning with the works of Mundell (1963) and Tobin (1965), one of the central issues in analyzing inflation and economic activity is its impact on productive capital. The Mundell-Tobin effect asserts that inflation affects the portfolio decision, causing individuals to hedge by substituting out of cash and into productive assets. This effect suggests that inflation and capital investment may be positively related. Market-clearing models, such as cash-in-advance models, say that inflation taxes all activities requiring cash, including the purchase of capital goods. These models predict that the capital stock should fall with higher inflation.

Shi (1999) considers this question in the context of a search model in which money is divisible yet every household has identical money balances at every point in time. That is, there is no distribution of money holdings as in Molico's approach. Shi accomplishes this model by treating a household as consisting of many members, each of whom either is a seller or holds an indivisible amount of money. Thus, while money is indivisible to a member of the household, it is divisible to the household, which makes decisions about how many goods to purchase with money and how many goods to sell for money. Search and matching occurs among the members of different households.[9]

Money growth and inflation in this model have an impact on capital through both the quantity of goods exchanged in each meeting between a buyer and seller (the intensive margin) and the numbers of buyers and sellers participating in the market (the extensive margin). The intensive margin results tend to conform with the prediction of market-clearing models of money; inflation taxes money and consumption and makes leisure more attractive than labor. Since capital and labor complement

each other in the production of goods and services, investment in productive capital declines as well. The extensive margin not present in these traditional models tell a different story, however. Just as in Li (1994, 1995), inflation creates an incentive to carry out transactions more quickly, increasing the number of buyers with money participating in the market. This rise increases the frequency of transactions and the incentives to produce and accumulate capital. If the inflation rate is low enough, the extensive effects of the model's search frictions can dominate the intensive effects. Thus, a Mundell-Tobin effect can exist for an appropriate range of low/moderate inflation rates, leading to a positive impact on productive activity.

Multiple Matching Models As an Alternative

Multiple matching models of money represent a new class of search-theoretic models of money designed with macroeconomic applications in mind. The framework, as developed by Laing, Li, and Wang (1999), departs from the prototype search models in some significant ways. Buyers are matched with a large (multiple) number of sellers instead of one to one. An analogy would be a shopper walking into a farmers market carrying goods and money and encountering many products and sellers. If the number of vendors in the farmers market is large enough, the buyer is always able to find barter and monetary trading opportunities. Since all individuals behave in a similar way, the advantage of our approach is that they will consume similar amounts and have identical money holdings (there are no distributions of money holdings or prices).[10]

Second, even though individuals still like to consume a small fraction of goods produced in the economy, they desire consumption variety and purchase a basket of goods. An example is a vegetarian who would prefer to buy carrots and broccoli instead of just broccoli. Because the number of sellers a buyer meets who satisfy the double coincidence of wants is small compared to those who may be willing to accept money, consumption variety is much smaller in a barter economy than in a monetary one. The use of money expands trading opportunities, allowing individuals to purchase a greater variety of goods.

Inflation, Employment, and Productivity Activity. Laing, Li, and Wang (2000) provide an example of how multiple matching models of money can shed new light on the links between monetary growth and productive activity. The study is motivated by empirical work showing that a consistently negative relationship between inflation, employment, and output is not found in the data across many countries. While it is true that periods of sustained inflation and hyperinflation disrupt productive activity, this observation tends not to apply to low-inflation countries (see Bullard and Keating 1995; Ahmed and Rogers 2000). To study this issue, Laing, Li, and Wang construct a multiple-matching model in which individuals must allocate their time between leisure, work, and investment in shopping (search) effort. Investing a greater amount of time in searching for goods, or shopping, increases the number of sellers one can meet in the farmers market and hence the variety of products available for purchase.

The results show that the importance of money in carrying out transactions plays a crucial role in how money growth and inflation affect productive activity. If money does not play an important role in overcoming trade frictions, or if these frictions are not too severe, a monetary expansion leads only to the inflation tax effect identified in traditional models of money. Individuals move away from market participation by both working and shopping less, and productive activity declines. However, if trade frictions are severe and money as a medium of exchange serves an important function, then increasing monetary growth can actually encourage productivity through its impact on trade and market participation. The intuition is that an increase in the inflation rate tends to erode purchasing power. One way individuals can compensate is to shop more intensely. By doing so, they meet with a greater number of sellers from whom to purchase greater consumption variety (that is, they compensate for the lower quantity of consumption with greater quality). This expansion of

8. Search theory has been applied in a different way to explain this phenomenon. In such an approach, sellers may be able to charge different prices for the same good because they are in different locations and have local monopoly power (Fishman 1992; Benabou 1992). Individuals must expend shopping resources to "search" for the best price. However, these models really have no use for money and treat price inflation as exogenous; that is, they are not macroeconomic models of money.
9. While the idea of a "large household" may at first seems strange and unrealistic, it appeals to the notion that the transactions between the members of a household in a given time period can be thought of as the many transactions an individual makes over the period as a buyer with money and a seller with goods.
10. This result comes from the statistical "law of large numbers." While the idea is similar to Shi's (1997), it does not involve a fictitious large household, appealing to the more realistic notion that individuals engage in a large number of transactions over time.

trading opportunities increases individual and firm participation in both the goods and labor markets, and these increases translate to an increase in overall employment and output.[11] If inflation is not too high, this result is consistent with the empirical Phillips curve, which depicts a negative trade-off between inflation and unemployment. However, this result is driven purely by the explicit role of money as a medium of exchange, not by assumptions of wages and prices rigidities common in Keynesian-style models.

Conclusion

Search-theoretic models of money formalize the role of money as a medium of exchange often ignored or not rigorously modeled in the traditional macroeconomic literature. These models explicitly capture the trade frictions that motivate the use of money in transactions and offer new insights into classic issues in monetary economics and macroeconomics as well as some issues, such as the use of multiple currencies, that cannot be addressed by the traditional models.

For example, a number of search-theoretic models of money predict that while high inflation is undoubtedly disruptive to economic activity, a small but positive amount of money growth and inflation can have beneficial effects on output and welfare. These benefits arise from the effect money and inflation have on the liquidity of the transactions process. At a very intuitive level, this prediction conforms with a conventional wisdom that a small amount of inflation can "lubricate" the gears of economic activity through promoting exchange between individuals and firms. Macroeconomic models that simply assert a transaction role for money overlook this aspect of money and inflation. Furthermore, the prediction is consistent with recent empirical evidence from Ahmed and Rogers (2000), among others, suggesting that inflation has had a positive long-run impact on consumption, output, and investment in low-inflation countries like the United States.[12] The progress search-theoretic models of money have made so far in investigating these issues demonstrates that why people use money is important to macroeconomics.

These macroeconomic applications also reveal the enormous potential of search models of money to address an even broader range of issues. So far, most of the results of these applications are qualitative. A quantitative analysis may not only explore the issue of how well these models explain the empirical facts regarding money and economic activity but may also provide guidelines for the operation of monetary policy.

For example, a natural question to study is, What is the "optimal rate of inflation" policymakers should target? Another related issue is, What do these models have to say about the interrelationship between money and credit markets? Thus far, work in this area has focused primarily on the nature of credit arrangements in search economies (Diamond 1990; Hendry 1992; Corbae and Ritter 1997), conditions under which individuals use both monetary and credit exchange simultaneously (Aiyagari, Wallace, and Wright 1996), and the role for privately issued currency, an issue that was especially important before the establishment of central banking in the United States (Cavalcanti, Erosa, and Temzelides 1999; Monnet 2001). These works suggest that search-theoretic models should be well suited to studying the economic consequences of the evolution of the payments system—for example, fiat money versus checks versus electronic money—and the role credit markets play in the way monetary policy affects macroeconomic activity.

11. These findings also indicate that in some situations, the model predicts that money growth may have either a positive or negative impact on productive activity, or multiple equilibria. This result may also explain why empirical work has failed to identify a consistent relationship between money growth and economic activity in low-inflation countries.
12. Ahmed and Rogers (2000) use over one hundred years of U.S. data to analyze the long-run empirical relationship between inflation and economic activity.

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