UNDERSTANDING UNCONVENTIONAL MONETARY POLICY: A NEW MONETARIST APPROACH

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ABSTRACT:

This paper focuses on Federal Reserve policy in the United States after the financial crisis. Three key interventions - QE1, QE2, and forward guidance - are reviewed, and a model is outlined that can be used to help understand some of the consequences of the financial crisis, and the policy responses to the crisis. Liquidity traps play an important role in the analysis, and it is shown how the financial crisis led to an unconventional liquidity shortage, requiring an unconventional policy response.

Keywords: Money, microfoundations, monetarism, monetary policy.

JEL Classifications: E40, E50

INTRODUCTION

Before the financial crisis in 2008-09 the academic economics profession perhaps seemed a well-ordered place. Economists were going about our business writing and publishing papers, debating economic issues at conferences and in the seminar room, and working with policymakers in an attempt to make the world a better place. There were disagreements of course, and sometimes those disagreements were heated, but the system seemed to be working. Mostly, good ideas appeared to be rising to the top, and academia's structure of peer review and incentives, though of course imperfect, seemed to be working to advance economic science.

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Since the financial crisis, the world appears to have changed, though maybe we are just seeing pieces of that world that we were unaware of. People who want to assign blame for the financial crisis have targeted economists, and macroeconomists in particular, with accusations of neglect, if not corruption. Within the profession, some economists have criticized particular economic research programs as being out of touch. Krugman (2009), for example, feels that much of the mainstream developments in macroeconomics and financial economics of the last 40 years are useless and should be relegated to the trash heap. Caballero (2011) argues that macroeconomic research has been too focussed on minor perturbations of the neoclassical growth model, and that there should be more experimentation in terms of research paths. A common complaint seems to be that there has been a neglect of the study of the financial sector and its role in aggregate economic activity.

Some macroeconomic researchers may indeed have been guilty of ignoring the details of financial arrangements in their work. For example, the researchers whose work appears in Kehoe and Prescott (2007) seem dismissive of the role of monetary and financial factors in depressive economic episodes. Also Woodford (2003), an influential handbook for monetary policy, focusses exclusively on the role of monetary policy in mitigating the frictions resulting from sticky prices, while ignoring monetary exchange and financial frictions. However, plenty of rigorous and well-respected research has been conducted over the last 40 years or more that addresses the role of private information and limited commitment in financial contracts and incentive contracts, examines the functions of financial intermediaries, highlights the role of assets in exchange, and integrates these ideas in macroeconomic frameworks that are amenable to policy analysis. Indeed, we do not have to dig deeply or look far afield to find top quality macroeconomic research on imperfect financial markets and to observe macroeconomists thinking outside the box.

In Williamson and Wright (2010, 2011), Randall Wright and I discuss the details of what we call "New Monetarist Economics," which is the area of macroeconomic research in which we work. We think of this research program as having two branches, one dealing with monetary economics, and the other with financial intermediation and banking, though in a sense our view is that this is all financial economics - a unified whole. Key contributions in the monetary economics research program are Kareken

and Wallace (1980), Kiyotaki and Wright (1989), and Lagos and Wright (2005), and key early contributions in the financial intermediation research program were Diamond and Dybvig (1983), Diamond (1984), Williamson (1986, 1987), and Bernanke and Gertler (1989), building on even earlier developments in information economics.

The key New Monetarist ideas are the following:

1. To understand how financial factors are important for aggregate economic activity, we need to delve into the particulars of private information and limited commitment frictions. Private information and limited commitment are at the foundation of the role for monetary exchange, and they are also key to understanding financial contracts, financial intermediation, and the financial propagation of macroeconomic shocks.

2. To analyze monetary policy requires that we construct models that explain how and why central bank liabilities and other assets are used in exchange, and to think carefully about how the central bank functions as a financial intermediary. Monetary policy works in part because of special advantages that a central bank has in intermediating assets - principally coming from monopolies on the issue of hand-to-hand currency and on payments systems arrangements among private financial institutions.

3. Attempting to classify some subset of assets as "money" is a futile exercise. We are interested in liquidity - broadly, some notion of how assets are used in exchange (retail exchange, wholesale exchange, exchange among financial institutions). Liquidity comes in many different forms. Some liquidity is supplied by the government, some by the private sector, and some assets are liquid in some circumstances but illiquid in others. In some transactions, for example the purchase of food from a street vendor, currency is the only object accepted in exchange, i.e. currency is highly liquid in this circumstance, but other assets are highly illiquid. However, in a large-value transaction involving financial institutions such as Bank of America and JP Morgan Chase, currency is highly illiquid while other assets such as US government Treasury bills and deposits with the Federal Reserve System (reserves) are highly liquid.

These three ideas set us apart, from Old Monetarists and New Keynesians in particular. Milton Friedman and the Old Monetarists thought

it important to categorize some assets as "money" and other assets as "not-money," and they did not appear very concerned with the role of financial intermediaries in the economy, other than as suppliers of "money." For New Keynesians, monetary and financial frictions are thought to be of minor importance in conducting monetary policy, though that idea may be changing (see for example Curdia and Woodford 2010) in response to the financial crisis.

In this paper, I use a particular New Monetarist model to help make sense of some features of the financial crisis, as well as to evaluate some of the policy interventions undertaken by the Federal Reserve System in the United States after the financial crisis. I will include only an outline of the specific model used here, and refer readers to Williamson (2011) for the details.

One key feature that our model has, which is crucial for understanding some features of the financial crisis, is a distinction between different types of liquid assets. In the model, currency is a liquid asset which is necessary to engage in particular kinds of retail transactions. However, intermediated loans and government bonds - interest-bearing assets - are also important liquid assets that are used in other types of transactions. In the model, when the central bank conducts a one-time open market operation, this can act in an unconventional way. If interest-bearing assets are scarce - where scarcity is defined in a precise way in the model - then a one-time open market purchase of interest-bearing assets by the central bank will lower the real interest rate permanently. This is an illiquidity effect, in that the open market purchase essentially makes interest-bearing assets more scarce. Typically, we would think of such an open market operation as an injection of liquidity, but in this instance it actually reduces liquidity by reducing the quantity of interest-bearing assets used in transactions.

The Federal Reserve System had been granted the power by Congress to pay interest on reserve accounts at the Fed, prior to the financial crisis. Beginning in October 2008, the Fed began paying interest on reserves at 0.25%, and that policy continues to the present date. Further, since the fall of 2008 when the Fed began to intervene in financial markets in a dramatic way, the quantity of excess reserves held by financial institutions in the United States has been very large. In such an environment, monetary policy works in a quite different way than in pre-financial crisis times. Under

current conditions, an extra unit of reserves in the financial system will be held overnight by financial institutions, and will have no marginal value in financial transactions during the day. Thus, if the Fed exchanges reserves for short-term government debt, that will be irrelevant, i.e. traditional central bank actions will have no effect. This does not mean, however, that there are no actions the Fed can take that will matter. Indeed, if the Fed changes the interest rate on reserves, then that essentially has the same effect as an open market purchase of short-term government securities would have had in the pre-financial crisis period.

The financial crisis is sometimes viewed as a puzzling event, which conventional economic theory cannot successfully confront. However, there is actually plenty of off-the-shelf economic theory that can be used to make sense of what we observed during the financial crisis. In particular, the model in Williamson (2011), which is used in this paper, uses financial intermediation theory developed primarily in the 1980s, by Townsend (1978), Diamond (1984), and Williamson (1986, 1987), and by Diamond and Dybvig (1983). It also makes use of monetary theory developed over the last 40 years or so. The costly state verification model of Townsend (1978) which gives rise to optimal debt contracts and can be used as an element in financial intermediary structures, is particular useful, as critical components of the financial crisis were non-contingent contracts, default, and the costs of bankruptcy. In this paper, we show how aggregate shocks to asset returns, risk, and the costs of bankruptcy can reproduce some key observations related to the financial crisis, in particular increases in interest rate spreads, declines in aggregate lending, and reductions in safe rates of interest.

These aggregate shocks work to explain features of the financial crisis, and also show how the scarcity of interest-bearing assets plays an important role in the financial crisis. Prior to the financial crisis, asset-backed securities played a key role in providing apparently safe liquidity in financial exchange. However, perceptions about the safety of those securities changed during the crisis so that, effectively, the private sector's capacity for producing safe liquid assets for financial exchange declined dramatically. This type of liquidity shortage is very different from the liquidity shortages that occurred during the Great Depression in the United States, or earlier, during the banking panics of the National Banking era (1863-1913). The Great Depression and National Banking era panics were

essentially currency shortages - a very different kind of liquidity scarcity. A currency shortage can be cured through standard open market purchases of interest-bearing assets, but such central bank actions will only aggravate the liquidity scarcity that existed during the financial crisis.

Once the Fed had lowered the interest rate on reserves to 0.25% in October 2008, there were essentially no conventional options open to the central bank to ease financial conditions in the United States. In this paper I will focus on three unconventional monetary policy interventions carried out by the Fed. The first two interventions are both typically referred to as "quantitative easing." Quantitative easing is a misnomer, first, as "quantitative" suggests that what makes this type of intervention differs by its quantitative nature, i.e. that asset quantities on the Fed's balance sheet are being manipulated. Of course, any action by a central bank, other than the setting of administered interest rates (the central bank's lending and deposit rates) involves quantities. In normal times, for example, most central banks intervene by targeting some overnight interest rate, and achieving that target by buying and selling quantities of assets. Second, as we will see in the paper, quantitative easing may not be easing anything.

The particular quantitative easing programs that the Fed engaged in are typically called "QE1" and "QE2." QE1 was a program of purchases of mortgage backed securities and agency securities by the Fed, while QE2 involved purchases of long-maturity federal government bonds (Treasury debt). These purchases were fundamentally different, as the first involved the indirect purchases of private assets, while the second was closely related to conventional open market operations with the only difference being that the asset purchases were long-maturity rather than short-maturity. In any case, the argument made in the paper is that there are conditions under which neither QE1 nor QE2 would have matters for any quantities or prices. It is possible that QE1 mattered, but this would only happen if the Fed were buying private assets on better terms than the private sector was offering. In that case QE1 would have altered the allocation of credit, and would have caused a redistribution of wealth.

A third unconventional intervention is "forward guidance." In recent years, the Fed has been somewhat more forthcoming in its policy statements concerning the future path of monetary policy, though typically the FOMC (Federal Open Market Committee) policy statement has supplied only vague

information, and that information would usually refer to potential policy decisions at the next FOMC meeting (about 6 weeks in the future). From the fall of 2008 until August 2011, forward guidance took the form of "extended period" language concerning the path of the policy rate in the future. For example, in the June 22, 2011 FOMC policy statement, the committee states that they continue "... to anticipate that economic conditions--including low rates of resource utilization and a subdued outlook for inflation over the medium run--are likely to warrant exceptionally low levels for the federal funds rate for an extended period." In its August 9, 2011 policy statement, the FOMC got much more explicit in stating that it "... currently anticipates that economic conditions--including low rates of resource utilization and a subdued outlook for inflation over the medium run--are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013." This is a very important change, as it essentially commits the Fed to a specific policy for a period of about 2 years.

This paper will first outline some recent monetary policy interventions, focusing on the United States and the US Federal Reserve System. Following that is a brief overview of a New Monetarist model, constructed in Williamson (2011). Following that, the objective is to show how that model can be used to organize our thinking about the financial crisis, and about conventional and unconventional monetary policy responses to the crisis.

Background: Federal Reserve Balance Sheet Developments, Three Key Unconventional Interventions, and the Mechanics of Monetary Policy

Tables 1 and 2 show a summary of the Federal Reserve System's assets and liabilities, at two different dates: January 2008 (pre-financial crisis) and August 2011. In Table 1, in January 2008 the liabilities of the Fed were structured much like they were at any date before the financial crisis. Currency was financing most of the central bank's asset portfolio, while financial institutions held a small quantity of reserves so as to satisfy reserve requirements. Indeed, reserves were small in January 2008 mainly because these financial institutions had found clever ways (such as sweep accounts) to circumvent reserve requirements. In January 2008, the US Treasury (the fiscal authority in the US federal government) maintained deposit accounts with the Fed, but at that time the balances in those accounts were small, in part to aid the Fed in monetary control.

As of August 2011, in Table 1, the Fed's liability structure had changed dramatically from the earlier period, with reserves accounting for the majority of Fed liabilities. Though the August 2011 data do not show it, Treasury account balances with the Fed have been substantial since the onset of the financial crisis - sometimes in excess of $300 billion - and have been highly volatile.

Table 1: Federal Reserve Liabilities ($billions)

	January 2008	August 2011
Currency	829	1036
Reserves	13	1649
Treasury Accounts	9	23

Source: Federal Reserve Bulletin

On the asset side of the Fed's balance sheet, in Table 2, the Fed's assets in January 2008 consisted mainly of US government debt, both short-term (Treasury bills or T-bills) and long-term (Treasury bonds or T-bonds). T-bills were used in day-to-day open market operations (often involving repurchase agreements) conducted by the Fed, and T-bonds were typically rolled over as they matured, but were not bought and sold on a daily basis.

As of August 2011, in Table 2, the average maturity of the Fed's assets had lengthened considerably from what it was prior to the financial crisis. In August 2011, the Fed held almost no T-bills, and had expanded its holdings of T-bonds considerably. Further, in August 2011 the Fed held about $1 trillion in assets that were essentially backed by private mortgage debt (and implicitly guaranteed by the federal government). In August 2001 the Fed held almost $900 billion in mortgage-backed securities issued by the government-sponsored enterprises or GSEs (actually now under government conservatorship): FNMA (or Fannie Mae) and FHLMC (or Freddie Mac). The agency securities on the Fed's balance sheet are the liabilities of these two GSEs.

Table 2: Federal Reserve Assets ($billions)

	January 2008	August 2011
T-bills	228	18
T-bonds	508	1616
Mortgage-Backed Securities	0	897
Agency Securities	0	112

Source: Federal Reserve Bulletin

Finally, of particular note is that the size of the Fed's balance sheet more than tripled from January 2008 to August 2011. The Fed is a much larger financial intermediary now than it was before the financial crisis.

Policy Interventions: QE1, QE2, and Forward Guidance

In this paper, attention will be focused on two particular interventions which are generally described as "quantitative easing," and typically referred to as QE1 and QE2. First, QE1 involved the purchase by the Fed of $1128 billion in mortgage-backed securities between February 2009 and July 2010 and the purchase of $169 billion in agency securities between September 2008 and April 2010. Second, QE2 was the purchase by the Fed of $600 billion in T-bonds between November 2010 and June 2011.

The bulk of the asset purchases associated with QE1 and QE2 are reflected in the reserve holdings of financial institutions in the United States. In Figure 1, we can see this most clearly for the later QE2 purchases. The QE1 program, though it accounts for a larger total asset purchase than does QE2, did not increase reserves as much, as the Fed was winding down its financial crisis lending interventions at the same time as it was purchasing assets.

More recently, the Fed announced on September 21, 2011 that it would engage in "Operation Twist." This is a planned sale of $400 billion

in T-bonds with remaining maturities of 3 years and less, in exchange for T-bonds with maturities of 6 to 30 years. The intervention will take place between September 2011 and June 2012. The result of operation twist will be to lengthen the average maturity of assets held by the Fed. While this may appear to be different from either QE1 or QE2, will show that, under current circumstances, Operation Twist is actually qualitatively identical to QE2.

Forward guidance, as discussed in the Introduction, involves statements by the central bank about the future course of policy. Prior to the financial crisis, Fed policy decisions concerned the setting of a target rate for the overnight fed funds rate, and communication with the public had evolved to the point where the FOMC policy statement would include some language which would signal the likely future path of the policy rate, and what that path might depend on. After the financial crisis, the Fed began to make more explicit statements about the future path for the policy rate, to the point where, in August 2011, the Fed essentially fixed the target policy rate for about two years.

How Does Fed Policy Work? Pre-Crisis and Post-Crisis

Most central bank intervention occurs roughly in the following way. If we focus just on overnight financial markets, the central bank lends to financial institutions overnight at a central bank lending rate, financial institutions can deposit funds (reserves) with the central bank overnight at a central bank deposit rate, and financial institutions can lend among themselves at a market overnight rate. There are basically three procedures that central banks typically exercise monetary control in the very short run. First, through open market operations, a central bank can intervene so as to target the overnight rate within bounds determined by the central bank lending rate (the upper bound) and the central bank deposit rate (the lower bound). This is a channel system, whereby the channel determined by the central bank lending and deposit rates "channels" the overnight rate. The Bank of Canada, for example, conforms to a channel system, and Figure 2 shows a forty-day period prior to early July 2011, illustrating the paths followed by the central bank lending rate, the central bank deposit rate, and the overnight market rate. In this case, the overnight rate was targeted at 1% over that period, and the Bank of Canada's deposit and lending rates were set, respectively, at 0.75% and 1.25%. Further, note that the Bank of Canada

managed, over this period, to conduct open market operations in such a way that there was little variability in the deviation of the overnight rate from the target. To accomplish this, the Bank needed to intervene so that funds were sufficiently tight in the system, with essentially zero reserves (deposits with the central bank) held overnight. As well, there needed to be sufficient availability of funds in the overnight market so that financial institutions did not want to borrow from the central bank at the lending rate. Under the Bank of Canada's channel system, the overnight market rate essentially determines all short-term interest rates in Canadian financial markets.

A second way to control short-term nominal interest rates is under a regime such as what exists currently in the United States. In October 2008, the Fed announced that it would begin paying interest on reserve balances and, since December 2008, the fed funds rate (the overnight market rate) has been targeted at 0-0.25%, with the Fed paying interest on reserves at 0.25%. As we see in Figure 1, the Fed had a large and increasing stock of reserve liabilities over this period. Under these circumstances, one would expect the fed funds rate to be 0.25% over the entire period. As in the Bank of Canada's channel system, the central bank's deposit rate should bound the overnight rate from below. In Figure 3, this is clearly not the case, as the fed funds rate has typically been significantly less than the 0.25%. However, it is nevertheless true that the interest rate paid on reserves currently determines all short-term interest rates. This is because the GSEs, who hold reserve accounts with the Fed, do not receive interest on the balances in those accounts, and there is some lack of arbitrage.[2] If the interest rate on reserves rises, we would expect the fed funds rate to rise with it.

A third alternative is for a central bank to control short-term market nominal interest rates by making the central bank lending rate the key policy rate. To do this, the central bank could essentially offer overnight loans at a particular interest rate, and then satisfy the demand for loans forthcoming at that rate. The central bank lending rate would then determine the overnight rate. The European Central Bank (ECB) operates somewhat like this through its refinancing operations, though it does not typically intervene daily to peg an overnight rate at the central bank lending rate.

2 The reasons for this lack of arbitrage appear to be something of a puzzle.

In conclusion, there are three ways for a central bank to influence short-term nominal interest rates, all working through the overnight market on which financial institutions trade. First, the central bank can intervene through open market operations to target the overnight rate such that it lies between the central bank's lending rate and the central bank's deposit rate. Second, the central bank can operate so that there is a positive quantity of central bank deposits (in excess of reserve requirements, if those exist) held overnight, in which case the central bank deposit rate determines the overnight rate. Third, the central bank could set a lending rate, and offer to satisfy all of the forthcoming demand at that rate and, further, set the rate in such a way that forthcoming demand is strictly positive. In this case, the central bank's lending rate determines the overnight rate.

Currently, the Fed operates according to the second regime. The financial system is awash in reserves, and the interest rate on reserves (the deposit rate at the central bank) is the key policy rate. In later sections we will explore how monetary policy works under these conditions.

A New Monetarist Model

This section contains an outline of the model. For more details readers should consult Williamson (2011). The basic structure of the model is similar to Rocheteau and Wright (2005), which in turn is derived from Lagos and Wright (2005). There is an infinite horizon with time indexed by t=0,1,2,3,..., with each period having two subperiods. We will refer to the first subperiod as the decentralized market or DM, and the second as the centralized market or CM. The population consists of three types of economic agents. First, there is a continuum of buyers, with unit mass, each of whom has preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t [u(x_t) - H_t]$$

Here, $0 < \beta < 1$, H_1 denotes the difference between labor supply and consumption in the CM, x_1 is consumption in the DM, and u(·) is a strictly increasing, strictly concave, and twice continuously differentiable function with $u(0) = 0$, $u'(0) = \infty$, $u'(\infty) = 0$, $-x[u''(x) / u'(x)] < 1$, for all $x > 0$, and with the property that there exists some $\hat{x} > 0$ such that $u(\hat{x}) - \hat{x} = 0$. Define x^* by $u'(x^*) = 1$. Second, there is also a continuum of sellers, with unit mass, each of whom has preferences

$$E_0 \sum_{t=0}^{\infty} \beta^t [-h_t + X_t]$$

where h_t denotes labor supply in the DM and X_t is consumption in the CM. When a buyer or seller can produce (the buyer in the CM, the seller in the DM), one unit of labor input produces one unit of the perishable consumption good.

Finally, the third group of agents are entrepreneurs. In each CM, a mass of these agents is born, and they live until the next CM. An entrepreneur has an indivisible investment project with payoff w and distribution $F(w)$, and payoffs are independent across entrepreneurs. For an individual entrepreneur, the realized payoff w is private information, but another agent can incur a verification cost γ to observe w. Entrepreneurs differ according to their observable verification cost, and $G(\gamma)$ describes the distribution of verification costs across entrepreneurs. Entrepreneurs do not consume in the CM when they are born, but consume in the subsequent CM, and are risk-neutral. Since he or she has no endowment, an entrepreneur must borrow when he or she is born in order to fund his or her investment project, which is a necessary condition to consume in the next CM. This costly state verification structure is very similar to what is built into the model in Williamson (1987).

In the decentralized market, each buyer is matched at random with a seller, while in the CM everyone is in the same location. In addition to the costly-state-verification information friction that will operate in the loan market, there are elements of imperfect information in the model that inhibit other types of lending. In the DM, sellers do not know the histories (i.e. relevant credit records) of buyers, which makes credit arrangements infeasible in DM meetings between buyers and sellers. Further, market participants in the CM can only observe prices.

In the model, there are three basic assets. First, there are loans to entrepreneurs. As is detailed in Williamson (1987, 2011), costly state verification, under some restrictions, implies that intermediated debt contracts with entrepreneurs are optimal, with perfectly-diversified delegated-monitoring financial intermediaries that hold portfolios of loans to entrepreneurs. For convenience, call these financial intermediaries banks. A loan to an entrepreneur with verification cost γ

will in equilibrium pay a gross real loan interest rate $R(\gamma)$, and $R(\gamma)$ will in general reflect a default premium that is increasing in γ . In equilibrium, the expected payoff to a bank from a loan to any entrepreneur will be r, the gross market real interest rate.

Further, some entrepreneurs will receive loans in equilibrium, while others do not. There is some critical value γ^* for the verification cost, such that some entrepreneurs with $\gamma \leq \gamma^*$ receive a loan, while those with $\gamma > \gamma^*$ do not. The gross real interest rate r is an endogenous variable. If r is higher, then this will imply that the cutoff γ^* is smaller, so that there is less lending. We can then write the aggregate loan quantity as $L = L(r)$, where $L(\cdot)$ is a decreasing function.

The other two assets are liabilities of the consolidated government (fiscal authority and central bank) - currency and one-period nominal government bonds. Let M_t denote the stock of money in period t, which trades at ϕ_t price in the CM, and B_t the stock of one-period nominal government bonds, each of which sells in the period-t CM for one unit of money, and pays off q units of money in the next CM in equilibrium. Banks will be indifferent between government bonds and loans to entrepreneurs in equilibrium, so in equilibrium we will have $r = \boldsymbol{r} = \frac{q\phi_{t+1}}{\phi_t}$.

In the DM, in fraction ρ of meetings - non-monitored meetings - between buyers and sellers, the information technology is not available to trade loans, government bonds (account balances with the fiscal authority), or the liabilities of intermediaries holding these objects as assets. Currency is the only asset that is tradeable in non-monitored meetings. However, in fraction $1 - \rho$ of meetings - monitored meetings - buyers and sellers have access to an information technology that allows them to exchange claims on entrepreneurs, bonds, currency, or claims to a portfolio of those assets. In all DM meetings, goods produced by the seller can be acquired by the buyer only through an exchange of assets. For convenience, we assume that the buyer makes a take-it-or-leave-it offer to the seller.

A bank in this model has a role to play in efficiently allocating liquidity to its best uses. Effectively, in the model there are two types of liquidity: currency on the one hand, and loans and government bonds - interest-bearing assets - on the other. In non-monitored DM meetings where only currency is accepted, loans and government bonds, or claims to them,

are useless. However, in monitored DM meetings where interest-bearing assets are accepted, it would be a poor choice to show up with currency. The currency would be accepted, but it will fetch fewer goods given its lower rate of return.

A problem a buyer faces in the CM is that, at the time production and consumption decisions are made, he or she does not know whether he or she will be in a non-monitored or a monitored meeting in the subsequent DM. However, this information will be revealed at the end of the CM. Thus a bank, in Diamond-Dybvig (1983) fashion, will be able to act to effectively provide liquidity insurance. Buyers each make a deposit in a bank in the CM when production and consumption occurs, the bank acquires a diversified portfolio of currency, government bonds, and loans to entrepreneurs, and then buyers learn what type of transaction they will need to make in the next DM. Buyers who will be in non-monitored meetings withdraw currency from the ATM, and buyers who will be in monitored meetings leave their deposit in the bank and then trade the deposit claim in the DM, i.e. they use their debit cards. In this way, currency is allocated to where it is needed - non-monitored meetings in the DM - while interest-bearing assets, which back bank deposits, are traded in monitored meetings.

To summarize, the timing of actions during a period is:

1. The CM opens.
2. Buyers work and acquire deposits in banks.
3. Banks acquire a portfolio of currency, government bonds, and loans to entrepreneurs.
4. Buyers each learn the type of meeting for the next DM.
5. Buyers requiring currency withdraw it from the ATM.
6. Buyers and sellers trade in the DM; non-monitored meetings involve exchanges of currency for goods; monitored meetings involve exchanges of bank deposits for goods.
7. In the next CM, banks dissolve and pay off their promises from the previous CM.

The last element of the model we need to specify is government policy. To keep things simple, restrict attention to a class of stationary policies, so that we can study the properties of stationary equilibria, in

which all real quantities are time-invariant. In particular, a government policy is defined by δ , μ where

$$M_t = \delta (M_t + B_t) \qquad 1)$$

$$M_{t+1} + B_{t+1} = \mu (M_t + B_t) \qquad (2)$$

where M_t and B_t denote the nominal quantities of currency and government bonds, respectively, in the CM in period t. In (1), δ denotes the fraction of total consolidated government liabilities, $M_t + B_t$ (currency plus government bonds held by the private sector), held as currency, and in (2), μ is the gross rate of growth of total consolidated government liabilities. The government can tax buyers lump-sum in the CM. See Williamson (2011) for details about the consolidated-government budget constraints and other elements of the relationship between fiscal and monetary policies.

Equilibrium

In a stationary equilibrium, a government policy *(δ, μ)* determines *r,m*, and *a*- the gross real interest rate, the real stock of currency, and the real stock of interest-bearing assets, respectively . The demands for currency and interest-bearing assets, m and a respectively, are determined by the behavior of banks, which acquire portfolios of currency and interest-bearing assets so as to maximize the expected utility of their depositors. Currency and government bonds are of course supplied by the government according to (1) and (2). The total demand for interest-bearing assets must equal the total supply of such assets, i.e. the bonds supplied by the government, *m (1 / δ – 1)* from (1) plus the quantity of loans made by banks *L(r)*, or

$$a = m(1/\delta - 1) + L(r) \qquad (3)$$

In this equilibrium, the gross inflation rate is μ, the gross real rate of return on currency is $1 / \mu$, the nominal interest rate is $r\mu - 1$, and arbitrage implies that $\frac{1}{\mu} \leq r \leq \frac{1}{\beta}$. A stationary equilibrium is unique, if it exists, and it will be one of four types:

1. Liquidity trap. In this equilibrium $\frac{1}{\mu} = r < \frac{1}{\beta}$, so the nominal interest rate is zero, and currency is not scarce relative to interest-bearing assets, but all assets are scarce.
2. *Plentiful interest-bearing* assets. In this equilibrium $\frac{1}{\mu} < r = \frac{1}{\beta}$, so the nominal interest rate is greater than zero, currency is relatively scarce, and interest-bearing assets are not scarce.
3. *Scarce interest-bearing assets*. In this case $\frac{1}{\mu} < r < \frac{1}{\beta}$, so the nominal interest rate is positive, currency is relatively scarce, and interest-bearing assets are scarce.
4. Friedman rule. Here, we have $\frac{1}{\mu} = r = \frac{1}{\beta}$, so the nominal interest rate is zero, and no assets are scarce.

In equilibrium, there are essentially two types of assets: currency and interest-bearing assets, and a scarcity of either type of asset can exist. Scarcity of an asset is in general reflected in a gross rate of return that is less than $1/\beta$, which is the gross rate of return on an asset sold in the current CM, paying off one unit of consumption goods in the next CM, and not accepted in exchange in DM transactions. Thus, "scarcity" refers to a scarcity in exchange in the DM. When an asset is scarce, buyers are willing to hold it in spite of the fact that its return is low, a notion that is familiar from standard monetary theory. Economists have known for a long time that "money" is held, in spite of its low return, because of its usefulness in transactions. Scarcity is further reflected in inefficient exchange in the DM. If currency is scarce, then the quantity of goods exchanged in non-monitored meetings in the DM is less than x^*, the surplus-maximizing quantity. If interest-bearing assets are scarce, then we get similarly-inefficient exchange in monitored DM meetings.

Liquidity Traps, Asset Scarcity, and Open Market Operations

The liquidity trap that most monetary economists are accustomed to thinking about arises in the Friedman rule equilibrium. When $\mu = \beta$, so that the total quantity of consolidated-government debt is declining at the rate of time preference, generating a deflation where the rate of

deflation is $1 - \mu$, there is a continuum of values for δ that support the same equilibrium allocation. That is, an increase in δ is a one-time open-market swap by the central bank of currency for government bonds, and this is irrelevant for the determination of quantities and prices.

A novelty in this framework is that there is another - and more relevant - type of liquidity trap, which arises in an equilibrium where interest-bearing assets are scarce. If interest-bearing assets are sufficiently scarce - and δ can always be chosen by the central bank to make them so - then μ can be determined in such a way that the rates of return on currency and interest-bearing assets are equal, i.e. the nominal interest rate is zero. Put more precisely, as is shown in Williamson (2011), for any $\mu > \beta$, δ can be chosen such that a liquidity trap equilibrium exists. Thus, the model tells us a liquidity trap is not an obscure phenomenon.

In a liquidity trap equilibrium, changing δ is irrelevant, i.e. at the margin a swap of outside money for interest-bearing assets has no effect on quantities or prices. The outside money injected is simply held by banks as reserves, replacing the interest-bearing assets one-for-one in banks' asset portfolios.

Asset scarcity is critical for analyzing the effects of open market operations in a "scarce interest-bearing assets" equilibrium. In Figure 4, we can illustrate what happens when δ increases in such an equilibrium, holding μ constant. Here, D represents the demand for interest-bearing assets as a function of the real interest rate r. Note that r is bounded by $1 / \mu$, the gross rate of return on currency, and by $1 / \beta$, the gross rate of return on a hypothetical safe asset that is not accepted in exchange. Start initially with curve S_1, which denotes the supply of interest-bearing assets determined by equation (3). Then, the intersection of D and S_1 determines the market gross rate of interest r and the quantity of interest-bearing assets a.

Increasing δ - a one-time open-market purchase of government bonds by the central bank - has the effect of shifting the supply curve to S_2. The open market purchase acts to increase the price level and to reduce the supply of nominal bonds outstanding, thus reducing the real stock of bonds and the total quantity of liquid interest-bearing assets, a. The result is an illiquidity effect, in that interest-bearing assets are now more scarce, the

real interest rate falls, and lending by banks to entrepreneurs expands, as the private sector responds to the scarcity of liquidity by producing more of it. Thus, there is a permanent nonneutrality of money, which is novel in the literature. This works much differently from, for example, typical Keynesian monetary transmission. In Keynesian frameworks, an open market purchase lowers the real interest rate and, under some circumstances that is a good thing. Here, the open market purchase makes interest-bearing assets more scarce, and that is bad for the efficiency of exchange.

The Financial Crisis

This is where the costly-state-verification delegated-monitoring intermediary structure becomes useful. That structure is an off-the-shelf piece of contracting/information/intermediation theory developed in the 1980s which can be put to work in understanding some features of the financial crisis, and in determining appropriate policy responses. In the model, it is possible to capture some elements of the financial crisis in terms of changes in the distributions $F(w)$ *and* $G(\gamma)$. Recall that these two objects describe the distribution of payoffs on an investment project for an individual entrepreneur, and the distribution of verification costs across entrepreneurs, respectively. We can interpret the investment projects in the model in quite general ways, for example to include mortgage lending, with the intermediated intermediary liabilities traded in monitored transactions in the DM then representing mortgage-backed securities, for example.

We can think of the financial crisis as affecting the distribution $F(\cdot)$ in two ways. First, anticipated returns on the underlying assets fell, which we can capture with a negative first-order-stochastic-dominance shift in $F(\cdot)$. Second, perceived risk was higher, which we can capture with a mean-preserving spread in $F(\cdot)$. Christiano, Motto, and Rostagno (2009) label this latter shock a "risk shock," and argue that risk shocks are generally important in capturing features of the aggregate time series, including the pre-crisis period. Williamson (1987) discusses risk shocks in the context of an intermediation sector similar to the one in this model (though missing the Diamond-Dybvig role for banks). In spite of the fact that the economic agents in the model are risk-neutral with respect to payoffs in the CM, these agents care about riskiness in $F(\cdot)$ because of the nature of debt contracts. A mean preserving spread tends to reduce the expected payoff for the bank conditional on the loan defaulting, but has no effect on the bank's payoff

in non-default states, when the bank gets a constant amount. As a result, the bank must be compensated, given the market gross real interest rate r, with a higher loan interest rate. This then implies that the entrepreneur will default with higher probability, or that it will no longer be profitable for the bank to lend to the entrepreneur.

In equilibrium, both types of shocks to $F(\cdot)$ act to increase the probability of default for borrowers, and to increase interest rate spreads (the difference between a gross loan interest rate and r). Further, these shocks act to shift the supply curve for interest-bearing assets, just as in Figure 4. The quantity of interest-bearing assets falls in equilibrium, because it is now more costly for the private sector to produce these assets, and r falls because interest-bearing assets are more scarce.

A third type of shock we can consider is a shift in $F(\cdot)$, in particular a positive first-order-stochastic-dominance shift, which will act to effectively increase verification costs for all entrepreneurs. This captures elements of the financial crisis, in particular the increased costs of collecting on debts, and a perceived loss in the potential value of collateral to financial intermediaries. This shift in $F(\cdot)$ has essentially the same effects as the two shocks to $F(\cdot)$ discussed above. Default premia rise for borrowers, interest rate spreads rise, lending falls, liquid interest-bearing assets become more scarce, and the safe real rate of interest falls. All of these are key features of the financial crisis.

What should government policy do in response to the financial crisis we have created in this model? The increasing scarcity of liquid interest-bearing assets in exchange has made exchange less efficient in the DM. This can be counteracted by shifting the supply curve in Figure 4 to the right. This can be done through conventional open market sales of government bonds by the central bank. This runs counter to what might seem a standard prescription, which is to "increase liquidity" during a crisis through open market purchases of government bonds by the central bank. The key idea here is that the liquidity shortage in the recent financial crisis was not a currency shortage, as for example during the Great Depression in the United States, or during the US banking panics of the late 19th century and the pre-Fed 20th century. A currency shortage would indeed be something that would be corrected through open market purchases of government bonds. However, the shortage of liquid assets during the financial crisis was a shortage of the safe liquid assets used in large financial trades, not a currency shortage.

Interest on Reserves

In analyzing Fed policy during and after the financial crisis, it is important to take account of the fact that the Fed has been paying interest on reserves since October of 2008. Incorporating interest on reserves in the model is actually very straightforward, provided we do not have to model the transactions role played by reserves during each day in large interbank transactions. For our purposes, leaving out the transactions role of reserve account balances is not a problem, since (as we showed in Figure 1) the financial system in the US is currently awash in reserves - the marginal transactions value of reserve balances is currently zero.

With interest on reserves, and positive reserve balances held by banks in equilibrium, in one sense the model behaves in exactly the same way, but policy works quite differently. In Figure 4, the central bank now determines r by setting the interest rate on reserves, i.e. given μ, the central bank sets Q, the gross nominal interest rate on reserves, and then $r = Q / \mu$. The central bank also sets the ratio of outside money (currency plus reserves) to total consolidated government liabilities. Then, the behavior of banks and buyers (depositors) jointly determines how outside money is split between currency and reserves, i.e. the private sector determines δ.

In this policy regime, conventional open market operations are irrelevant, just as in the liquidity trap equilibrium discussed above, but here the irrelevance occurs no matter what the interest rate on reserves is - this interest rate can be positive and large. A swap of interest-bearing reserves for government bonds is irrelevant because these two assets are identical from the point of view of a bank. However, the central bank is not powerless in this regime, as it can change the interest rate on reserves. For example, in Figure 4, the central bank can lower the interest rate on reserves, which serves to lower r in equilibrium. The supply curve now shifts from S_1 to S_2, not because of a conventional open market purchase, but because the private sector now holds less reserves, in real terms, and the quantity of interest-bearing assets, a, falls.

QE1: Purchases of Private Assets

There are some differences in central bank operating procedure in the world, driven in part by institutional differences in the environments

in which central banks operate, but central banks typically restrict their asset purchases to the government debt of the central government(s) in their jurisdictions. As discussed earlier, QE1 in the United States was out of step with that tradition.

Why do central banks typically not purchase private assets? If asset purchases can indeed change asset prices, then the central bank can potentially move prices in a way that favors those who are holding the particular assets the central bank is purchasing. The central bank could for example increase the relative value of particular stocks, by purchasing those assets. Or it could increase the price of the debt issued by a particular corporation, while decreasing the price of the debt issued by other entities. Thus, the central bank can redistribute wealth and reallocate credit in ways that favor some individuals while hurting others. This leaves the central bank the potential subject of political influence, and threatens its independence.

In purchasing private assets, a central bank faces the same kinds of private information problems as do private sector intermediaries. The quality of private assets may be hard to discern, and there are moral hazard problems - private sector economic agents may be willing to dupe a naive central bank into accepting poor-quality assets.

In the case of QE1, it seems safe to rule out problems associated with private information frictions. The private asset purchases of the Fed were either direct obligations of the GSEs, or mortgage-backed securities created by the GSEs. At the time of the QE1 purchases, the GSEs were under US government conservatorship, and the quality of the assets appeared to be solid.

What happens in our model when the central bank purchases private assets? Capturing the nature of QE1, suppose that the central bank has the same costly-state-verification technology as do private banks, and acquires a portfolio of loans to entrepreneurs, with the contracts written in an identical fashion to how the private sector would write them. If the central bank were to acquire such a portfolio on the same terms as the private sector is offering, financing the purchases by issuing outside money, then this would have no effect on quantities or prices. The central bank intermediates private loans on the same terms as does the private sector, thus displacing private sector lending one-for-one. The stock of reserves (and thus outside

money) increases one-for-one with the asset purchases, but there are no effects on prices, just as appeared to be the case in response to the real-world QE1 purchases. The central bank is always able to pay the interest on reserves with the returns on its portfolio. These results are of course contrary to Old Monetarism, under which increases in the measured money stock increase prices.

But what if the central bank buys assets on better terms than what the private sector is offering? In this case, the central bank is in fact able to expand the supply of credit, but it will now make a loss on its portfolio. How those losses are made up is critical, but in any case the central bank will bring about a reallocation of credit and a redistribution of wealth - some are better off as a result and some are worse off. The QE1 program indeed seemed intended to favor a particular sector of the economy - the housing sector. While there may have been some beneficial effects in terms of stemming the deadweight losses from defaults, our analysis indicates the possibility that QE1 was either ineffective, or had important unrecognized opportunity costs.

Following the end of the QE1 program, the Fed had been allowing the quantities of mortgage-backed securities and agency securities to fall, as prepayments and defaults occurred on the underlying mortgages. However, in at the September 21, 2011 meeting of the FOMC, the committee members decided to replace these maturing securities with new purchases of mortgage-backed securities for the foreseeable future. Given our analysis here, this seems to be a poor policy decision.

QE2: Purchases of Long-Maturity Government Securities in Exchange for Reserves

The QE2 program discussed previously involved swaps by the Fed of reserves for long-maturity government securities. As such, our model is not quite equipped to deal with it, as we have not included long-maturity debt. However, we can argue informally, using the same principles that guided the construction of the basic model.

Central banking matters because of particular advantages the central bank has over the private sector in financial intermediation. In the United States, the Fed's advantages stem from its monopolies in the

issue of currency and in the provision of payments system services. The liabilities of the Fed - currency and reserves - each serve a transactions role in exchange that private liabilities cannot. There is no substitute for currency in some types of retail transactions, and essentially all domestic large-value payments among financial institutions are settled on Fedwire, which permits the transfer of the balances in Fed reserve accounts.

In the context in which QE2 was executed, it had to be neutral, i.e. it had no effect on any quantities or prices. Why? As discussed above, at the time of the QE2 asset-purchase program, the Fed was paying interest on reserves, and there was a very large stock of excess reserves held by financial institutions. In that case, a swap of interest-bearing reserves for long-maturity Treasury bonds increased the quantity of a particular type of financial intermediation on the Fed's part, i.e. the function of transforming long-maturity government debt into overnight-maturity assets. However, the private sector can perform that function as well as the Fed can. Any private sector financial institution can create a special-purpose-vehicle (SPV) that holds long-maturity Treasury securities and finances that asset portfolio with overnight repurchase agreements (overnight lending with the Treasury securities used as collateral) that the SPV rolls over every day. It is a general principle that, if there is a government activity that is a perfect substitute for a private activity, and the government engages in more of that activity, then the level of the private sector activity drops by a commensurate amount, and nothing changes as a result. The same applies to QE2.

This is essentially a kind of Modigliani-Miller result (see Modigliani and Miller 1958). Other types of Modigliani-Miller results in the literature on macroeconomics are the Ricardian equivalence theorem (Barro 1974) and Wallace (1981).

On September 21, 2011, the FOMC announced a new quantitative easing program, dubbed Operation Twist, after a similar intervention by the Fed in the early 1960s. From September 2011 to June 2012, the Fed plans to sell $400 billion in Treasury bonds with maturities of 3 years or less, in exchange for T-bonds with maturities of from 6 years to 30 years. In doing so, the Fed believes that it can lower long-term Treasury yields. Effectively, this program is qualitatively identical to QE2, i.e. it is a swap of short maturity consolidated-government debt for long-maturity government debt. As such, we would expect it to have no effect. Fed officials argue that

Operation Twist will have the intended effects based on event studies and astructural regression results, but they do not have a serious theory nor structural econometric evidence to support the change in policy.

Forward Guidance

Forward guidance could certainly be incorporated in our model, but we can use informal arguments here, as the ideas are not model-dependent. In the 1970s, macroeconomic research began to stress the importance of views of private-sector economic agents about the future for economic policy. Beginning with the work of Kydland and Prescott (1977), there was increasing stress on the role of commitment for macroeconomic policymaking. Macroeconomists have come to understand that their commitment to an explicit or implicit policy rule is key to the effects of monetary policy.

In some countries, the central bank is explicitly committed to a specific policy goal. For example, central banks in Australia, Canada, New Zealand, and the U.K., have explicit inflation targets. The Fed has never had an explicit target or targets of any kind, but is governed by the so-called "Humphrey Hawkins Act" of 1978. This specifies a "dual mandate," which is typically interpreted in FOMC statements as a commitment to "maximum employment and price stability." Statements by Fed officials tend to point to an implicit target for the inflation rate of about 2% per year.

It is widely recognized that, whatever the Fed's implicit policy rule is, that it act in a manner that is consistent with that implicit rule, so that the private sector can come to understand it. Taking policy actions that are inconsistent with previous Fed actions can only lead to confusion in the private sector and poor macroeconomic performance. This is what makes the FOMC's decision on August 9, 2011 troubling. As pointed out by Narayana Kocherlakota (2011), President of the Minneapolis Federal Reserve Bank, who dissented on August 9, the decision to commit to an interest rate on reserves of 0.25% for the next 2 years (roughly), was inconsistent with previous FOMC decisions, based on the state of the economy. Further, while that decision might be interpreted as providing more commitment by the Fed, it actually provided less. As long as the public clearly understands the relationship between central bank actions and the state of the economy, then the Fed is providing all the forward guidance that is necessary. By taking an action that departs from what would be dictated by the previous policy rule, the Fed only sows confusion, and defeats the purpose.

Conclusion: The Fed's Monetary Policy Future

What can we conclude? In one sense the picture is somewhat reassuring. While an Old Monetarist might view the size of the Fed's balance sheet and the huge recent growth in the stock of outside money as alarming, there is a sense in which the size of the balance sheet does not matter. Further, while asset swaps by the central bank that would normally matter are now ineffective, the Fed actually has all the monetary control it needs by setting the interest rate on reserves appropriately. However, the Fed is limited, in that the interest rate on reserves cannot go below zero, and the Fed was not granted the power by Congress to charge fees on reserve accounts, which would otherwise permit a negative net interest rate on reserves.

The Fed has committed errors. Those errors were in making confident claims concerning the effectiveness of QE1 and QE2, in the absence of sound theory and convincing empirical evidence, and in taking policy actions inconsistent with its previous behavior. Further, Fed officials continue to argue that they have a large toolbox - including the use of reverse repurchase agreements and term reserve accounts - that can be brought to bear in improving economic welfare, when in fact the Fed's options are extremely limited.

The Fed has only one policy tool under current circumstances (a positive stock of excess reserves in the financial system), and that tool is the interest rate on reserves. A complication is that, when Congress permitted the payment of interest on reserves, it gave the Board of Governors the power to set the interest rate on reserves, when that power would have more appropriately rested with the FOMC. Potentially, there could be a conflict between the FOMC and the Board about changes in the policy rate, when the intent of the original Federal Reserve Act was to give decision-making power to the FOMC.

Currently, the Fed is doing significant harm to its credibility by engaging in interventions it does not understand well, and in arguing that it has tools that it does not in fact have. I am somewhat pessimistic about the Fed's future, and I hope I am wrong.

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