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ABSTRACT

This paper reviews the unconventional U.S. monetary policy responses to the financial and real crises of 2007-09, divided into three groups: interest rate policy, quantitative policy, and credit policy. To interpret interest rate policy, it compares the Federal Reserve's actions with the literature on optimal policy in a liquidity trap. The theory suggests that, to minimize the length and severity of the recession, would require a stronger commitment to low interest rates for an extended period of time. To interpret quantitative policy, the paper reviews the determination of inflation under different policy regimes. The main danger for inflation from current actions is that the Federal Reserve may lose its policy independence; a beneficial side effect of the crisis is that the Friedman rule can be implemented by paying interest on reserves. To interpret credit policy, the paper presents a new model of capital market imperfections with different financial institutions and a role for securitization, leveraging, and mark-to-market accounting. The model suggests that providing credit to traders in securities markets can restore liquidity with fewer government funds than extending credit to the originators of loans.

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The last two years have been an exciting time to be a student of monetary policy and central banking. Variability in the data is what allows us to learn about the world, and variability has not been in short supply in the United States, with wide swings in asset prices, threats to financial stability, concerns about regulation, sharply rising unemployment, and a global recession. But these have been difficult times to be a central banker. The limited tools at the disposal of the Federal Reserve have been far from sufficient to put out so many fires, and many of the challenges have caught central bankers unprepared for what not so long ago seemed highly improbable.

This paper reviews the Federal Reserve's actions in 2007-09 and interprets them in the light of economic theory. "Interpret" is the operative word here, since any attempt to describe and evaluate all that has happened would be doomed to fail. On the one hand, so much has already happened that it would take a book, or perhaps many books, to describe and account for it all. On the other hand, the crisis and its reprecussions are far from over, so that any assessment runs the risk of quickly becoming obsolete. I will therefore avoid, as far as I can, making pronouncements on what policies seem right or wrong, even with the benefit of hindsight, and I will not give a comprehensive account of all the events and policies. My more modest ambition is to provide an early summary of monetary policy's reaction to the crisis thus far, to interpret this reaction using economic theory, and to identify some of the questions that it raises.

I start in section I with brief accounts of the crisis and of the Federal Reserve's responses. These fall into three categories. The first is interest rate policy and concerns the targets that the Federal Reserve sets for the interest rates that it controls. Figure 1 illustrates the recent changes by plotting two key interest rates targeted by the Federal Reserve over the last 20 years. These rates are as low today as they have been in this entire period, and the Federal Open Market Committee (FOMC) has stated its intent to keep them close to zero for the foreseeable future.[1]

[figure 1 about here]

Figure 2 illustrates the second set of policies, which I label quantitative policy. These involve changes in the size of the balance sheet of the Federal Reserve and in the composition of its liabilities. The figure plots an adjusted measure of reserves held by banks in the Federal Reserve system and the monetary base (currency plus reserves), both as ratios to GDP, since 1929. In September 2009 adjusted reserves were equal to 6.8 percent of GDP, a value exceeded in the history of the Federal Reserve System only once, between June and December 1940. The monetary base is as large relative to GDP as it has ever been in the last 50 years.

[figure 2 about here]

The third set of policies, which I label credit policy, consists of managing the asset side of the Federal Reserve's balance sheet. To gauge the radical change in the composition of these assets since the crisis began, figure 3 plots the ratios of U.S. Treasury bills and of all Treasury securities held by the Federal Reserve to its total assets.[2] From a status quo where the Federal Reserve held almost exclusively Treasury securities, in the last two years it has switched toward holding many other types of assets and, more recently, toward securities with longer maturity.

[figure 3 about here]

I start my assessment in section II with this last group of policies, because they are the least understood in theory. Using a new model of capital markets, I investigate the effects of the Federal Reserve's different investments on the availability of credit.[3] In the model, four groups of actors—entrepreneurs, lenders, traders, and investors—all have funds that must be reallocated through the financial system toward investment and production, but frictions among these groups may lead to credit shortages at different points in the system. Different credit programs implemented by the central bank will have different effects depending on whether they tighten or loosen these credit constraints, and depending on the equilibrium interactions between different markets. Drawing on the model, section III goes on to suggest that whereas the Federal Reserve's credit policies to date have been directed at a wide range of markets and institutions, focusing the central bank's efforts on senior secured loans to traders in securities markets would be the most effective way to fight the crisis.

Next, in section IV, I move to quantitative policy and ask the following question: do the recent increases in reserves and in the central bank's balance sheet undermine the ability of the current policy regime to control inflation? I show that according to a standard model of price-level determination, the regime is threatened only if the Federal Reserve becomes excessively concerned with the state of its balance sheet, or if it gives in to pressure from the fiscal authorities, effectively surrendering its independence.

Finally, in section V, I turn to interest rate policy. I briefly survey the literature on optimal monetary policy in a liquidity trap, which recommends committing to higher than normal inflation in the future and keeping the policy interest rate at zero even after the negative real shocks have passed. Although the Federal Reserve's actions fit these prescriptions qualitatively, the theoretical model developed below suggests that a stronger commitment to low interest rates for a prolonged period of time would have a strong stimulative effect. Section VI concludes.

I. What Has the Federal Reserve Been up to?

There are already some thorough descriptions of the events of the U.S. financial crisis of 2007-09.[4] After a brief and selective summary, this section catalogs the policies followed by the Federal Reserve in response to these events.

I.A. The Financial Crisis and the Real Crisis

In August 2007 an increase in delinquencies in subprime mortgages led to a sharp fall in the price of triple-A-rated mortgage-backed securities and raised suspicions about the value of the underlying assets. Because many banks held these securities, either directly or through special investment vehicles, doubts were cast over the state of banks' balance sheets generally. Through 2007 the fear became widespread that many banks might fail, and interbank lending rates spiked to levels well above those in the federal funds market. This increase in risk spreads diffused over many markets, and in a few, notably the markets for commercial paper, private asset-backed securities, and collateralized debt obligations, the decline in trading volume was extreme, apparently due to lack of demand.

In the real economy, the U.S. business cycle peaked in December 2007, according to the National Bureau of Economic Research. Unemployment began rising steadily from 4.9 percent in December of 2007 to just over 10 percent in October 2009, and output decelerated sharply in 2008Q1. Net acquisition of financial assets by households fell from $1.023 trillion in 2007 to $562 billion in 2008 and to just $281 billion and $19 billion in the first two quarters of 2009, respectively. As of the start of 2008, however, there was still no sharp fall in total bank lending.

In March 2008 the investment bank Bear Stearns found itself on the verge of bankruptcy, unable to roll over its short-term financing. The government, in a joint effort by the Federal Reserve and the Treasury, stepped in and arranged for the sale of Bear Stearns to JP Morgan Chase, providing government guarantees on some of Bear Stearns' assets. Risk spreads remained high, and the asset-backed securities market was effectively closed for the rest of the year, but some calm was returning to markets until the dark week of September 15 to 21 arrived.

The extent of the crash during these seven days probably finds its rival only in the stock market crash of October 1929. It was marked by three distinct events. The first, on September 15, was the bankruptcy of Lehman Brothers, the largest company ever to fail in U.S. history. This investment bank was a counterparty in many financial transactions across several markets, and its failure triggered defaults on contracts all over the world. The second event was the bailout of American International Group (AIG), one of the largest insurance companies in the world, on the evening of September 16. The bailout not only signaled that financial losses went well beyond investment banks, but also increased the uncertainty about how the government would respond to subsequent large bankruptcies. The third event, on September 20, was the announcement of the first version of the Troubled Asset Relief Program, or TARP (also known as the "Paulson plan" after Treasury Secretary Henry Paulson), which, although potentially far-reaching, was both short on detail and vague in its provisions.

In the six months that followed, the stock market plunged: the S&P 500 index fell more than 56 percent from its peak in October 2007 to its trough in March 2009. Most measures of volatility, risk, and liquidity spreads increased to unprecedented levels, and measures of real activity around the world declined. Which of the three events was the main culprit for the financial crisis that followed is a question that will surely motivate much discussion and research in the years to come.[5]

Through all these events, the Treasury cooperated with the Federal Reserve while also pursuing its own policies in response to the crisis. Today, these include a plan to invest up to $250 billion in banks to shore up their capital, assistance to homeowners unable to pay their mortgages, and up to $100 billion of TARP money in public-private investments to buy under-performing securities from financial institutions. Since March 2009 some stability has returned to financial markets, with risk spreads shrinking and the stock market partly recovering. Forecasts of unemployment and output, however, have yet to show clear signs of improvement.

Finally, inflation as measured using the year-on-year change in the consumer price index has fallen from 4.1 percent in December 2007 to -1.3 percent in September 2009. Inflation forecasts for the coming year, as indicated by the median answer in the Survey of Professional Forecasters, have fallen from 3.6 percent in the last quarter of 2007 to 0.7 percent in the third quarter of 2009, and the forecast for average inflation over the next 10 years has risen slightly, from 2.4 percent to 2.5 percent.

I.B. The Federal Reserve's Actions during the Crisis

The Federal Reserve typically chooses from a very narrow set of actions in its conduct of monetary policy. It intervenes in the federal funds market, where many banks make overnight loans, by engaging in open-market operations with a handful of banks that are primary dealers. These operations involve collateralized purchases and sales of Treasury securities, crediting or debiting the banks' holdings of reserves at the central bank. The Federal Reserve announces a desired target for the equilibrium interest rate in the federal funds market and ensures that the market clears close to this rate every day.

Over the course of the last two years, however, the Federal Reserve's activities have expanded dramatically. Table 1 provides snapshots of these recent actions at three points in time: in January 2007, before the start of the crisis (and representative of the decade before); at the end of December 2008, in the midst of the crisis; and in August 2009. The Federal Reserve's policies fit into three broad categories.[6]

The first is *interest rate policy*. Starting from a target for the federal funds rate of 5.25 percent for the first half of 2007, the Federal Reserve gradually reduced that target to effectively zero by December 2008.[7] In its policy announcements, the Federal Reserve has made clear that it expects to keep this rate at zero for an extended period.[8] Starting in October 2008, the Federal Reserve has also been paying interest on both required and excess reserves held by commercial banks; since December 2008 the interest rate on these reserves (shown in figure 1) has been the same as the federal funds rate target. This implies that banks no longer pay an effective tax on reserves held at the central bank beyond the legal requirements. It also means that the Federal Reserve in the future has at its disposal a new policy instrument, the spread between the federal funds rate and the rate on reserves.[9] Finally, the Federal Reserve has purchased other securities with the stated intent of affecting their prices and yields, but there is little evidence of success.[10]

The second category, which I label *quantitative policy*, concerns the size of the Federal Reserve's balance sheet and the composition of its liabilities. Historically, the bulk of these liabilities has consisted of currency in circulation plus bank reserves (most of which the banks are required by law to hold at the level mandated by the Federal Reserve) and deposits of the Treasury and foreign central banks. With the onset of the crisis, the first change in quantitative policy was that the Federal Reserve's balance sheet more than doubled. Reserves accounted for much this increase and are now mostly voluntary, since the penalty for holding reserves instead of lending in the federal funds market effectively disappeared once the interest rates on both became the same. The other significant change was that the U.S. Treasury became the single largest creditor of the Federal Reserve. As a means of providing the Federal Reserve with Treasury securities to finance its lending programs, the Treasury has greatly expanded its account, and in August 2009 it held more than one-tenth of the Federal Reserve's total liabilities.

The third category is *credit policy*. This consists of managing the composition of the asset side of the Federal Reserve's balance sheet. At the start of the crisis, the central bank's assets were similar in composition to what they had been since its founding: mostly U.S. Treasury securities, with over one-third in Treasury bills and the remainder made up of Treasury bonds and notes together with modest amounts of foreign reserves. Rounding out the balance sheet were modest amounts of foreign reserves and other assets (such as gold), but almost no direct loans. By the height of the crisis in December 2008, however, this picture had changed dramatically, following the announcement of several new asset purchase programs[11]

The Federal Reserve's December 31, 2008, balance sheet reveals several important changes in its assets from two years earlier. Starting from the top of the assets column, the first is a significant shift in the average maturity of Treasury securities held from short to long. The second is a dramatic increase in direct loans, with the Federal Reserve for the first time lending directly to entities other than banks. These included loans to primary dealers through the 28-day TSLF and the overnight PDCF and, through the TALF, to investors posting as collateral triple-A-rated asset-backed securities on student loans, auto loans, credit card loans, and Small Business Administration loans.[12] The third is an almost 30-fold increase in foreign reserves, reflecting a swap agreement with foreign central banks to temporarily provide them with dollars against foreign currency. The next three changes take the form of entirely new asset categories. First, through the TAF, the Federal Reserve started lending to banks for terms of 28 and 84 days against collateral at terms determined at auction. These auctions provide a means to lend to banks that preserves the recipients' anonymity, to prevent these loans from being seen by the market as a signal of trouble at the debtor bank. In December 2008 these credits to banks accounted for almost one quarter of the Federal Reserve's assets. Second, through the CPFF, the Federal Reserve bought 90-day commercial paper, thereby financing many companies directly without going through the banks. Finally, the Federal Reserve created three limited-liability companies, Maiden Lane LLC and Maiden Lane LLC II and III, to acquire and manage the assets associated with the bailouts of AIG and Bear Stearns.

By August 2009 some of these programs had been reduced significantly in scope, in particular the holdings of commercial paper and foreign reserves. Others, however, continue to grow. In particular, in March 2009 the Federal Reserve announced it would purchase up to $300 billion in long-term Treasury bonds and $1.45 trillion in agency debt and mortgage-backed securities; it expects to reach these goals by the end of the first quarter of 2010. These changes were announced at the FOMC meeting of March 2009 but had been under discussion for a few months before that. A large share of these purchases is already reflected in the August balance sheet.

II. A Credit Frictions Model of Capital Markets

The crisis of 2007-09 has witnessed credit disruptions involving multiple agents in many markets, it has seen large swings in asset-backed securities, and it has propagated from financial markets to the real economy. Unfortunately, no off-the-shelf economic model contains all of these ingredients. Before I can interpret the Federal Reserve's policies, I must therefore take a detour to introduce a new model that captures them.

Financial markets perform many roles, including the management of risk and the transformation of maturities. In the model I abstract from these better-understood roles to focus on another role of financial markets: the reallocation of funds toward productive uses. I take as given a starting distribution of funds across agents, and I study how trade in financial markets shifts these funds to where they are needed, subject to limits due to asymmetries of information. The model merges insights from the theory of bank contracts based on limited pledgeability (Holmstrom and Tirole 2009) with the theory of leverage based on collateral constraints (Kiyotaki and Moore 1997; Matsuyama 2007). It is a simpler version of a model fully developed in Reis (2009). The appendix lays out the model in more detail.

II.A. Setting up the Model: Agents

The model has three periods, no aggregate uncertainty, and a representative consumer-worker. She supplies labor L in all three periods, earning a wage W in each period, and consumes a final good C'' in the last period, which is a Dixit-Stiglitz aggregator of a continuum of varieties. The economy has only one storable asset, in amount H, which I will refer to as capital. It consists of claims issued by the government, which can be redeemed for the consumption good in the final period. The government levies a lump-sum tax on the representative household in the last period to honor these claims.[13]

The representative household has four different types of financial agents, each endowed with an initial allocation of capital. First, there are many *investors* behaving competitively, who hold capital M.

Agents of the second type are *entrepreneurs*. There is a continuum of them in the unit interval associated with each variety of the consumption good. In the first period they must hire F units of labor to set up operations. Further labor is then hired in the second and third periods, to produce monopolistically in the last period a variety of consumption goods in amount Y_i''. The production function is

(1)
$$Y_i'' = A_i' \min\left\{\frac{L_i'}{v}, \frac{L_i''}{1-v}\right\}.$$

At the optimal choice of labor in the second and third periods, v will be the fraction of labor employed in the second period. Exogenous productivity, A_i', is independently and identically distributed across the continuum of firms and is revealed in the second period, before the labor decision is made for that period. With probability $1 - \varphi$ it equals a, and with probability φ it is zero. Therefore, if $I \in [0, 1]$ projects are funded in the first period, only $N = (1 - \varphi)I$ yield positive output in the last period.

This production structure captures the maturing process of investments, with expenses incurred in every period in order to obtain a payoff in the last period, together with the risk that setup costs may not be recouped if the technology turns out to be worthless. The entrepreneurial capital available is K, which is smaller than WF, so that entrepreneurs must seek outside financing.

Agents of the third type are *lenders*. Their distinguishing feature is that only they have the ability to monitor the behavior of entrepreneurs. If investors were to finance entrepreneurs directly, they could not prevent them from running away with all of the funds. Lenders, in contrast, can prevent the entrepreneurs from absconding with more than a share δ of sales revenue. Entrepreneurs can therefore pledge $1 - \delta$ of this revenue to lenders and zero to all other agents.[14] I assume that the pledgeable revenue is enough to ensure positive pledgeable profits to lenders. A lender will provide the capital needed to start the project, $WF - K$, as well as a line of credit in the second period to pay wages WL'.

To fund these investments, lenders have capital D in the first period and may receive a new infusion D' in the second period. If they require further financing, they can issue and sell securities, guaranteed by the loans they make, totaling S for price Q in the first period, and S' for price Q' in the second period.[15] These securities pay one unit of capital in the last period, if the project is in operation. In the data, lenders include all providers of financing to the nonfinancial sectors, including commercial banks, primary issuers of commercial debt, some brokers, and others.

Traders are the fourth and final group of agents. Although they cannot monitor loans, together with lenders they have the unique ability to understand and trade the lenders' securities. In particular, in the first period, lenders could try to sell as many securities as they wanted whether they had proper backing or not. Traders are the only agents who can verify that a recently issued security has proper backing. Traders also observe the realization of productivity in the second period, whereas investors do not. They therefore perform the role of intermediating between lenders and investors so that the latter have access to the securities. In the United States, traders include investment banks, hedge funds, special investment vehicles set up by commercial banks, and many others.

Traders have capital E in the first period, and an additional E' is available to them in the second period. They can also obtain funds from investors, but I assume that another friction prevents investors from effectively owning the traders and acquiring access to their information technology. I again use a pledgeability constraint, assuming that investors can seize at most a share $1 - \mu$ of the assets of a trader, so that this is the trader's maximum liability.[16] Therefore, in the first period, the trader's total assets are E/μ, where μ gives the inverse of the leverage multiplier. In the second period, because traders enter with assets equal to the securities S, and these are marked to market, their entering equity is E + [(1 –

$\varphi)Q' - Q]S/Q$, reflecting the capital gain (or loss) made on these investments. Because the trader can get new loans against this marked-to-market equity position, the trader can invest a further $[(1 - \mu)/\mu)][(1 - \varphi)Q'/Q - 1]S$ in the second period. This ability to use capital gains to boost leverage is also emphasized by Arvind Krishnamurthy (forthcoming) and by Andrei Shleifer and Robert Vishny (2009).[17]

II.B. Setting up the Model: Financial Markets

Having presented the agents, I now describe the markets in which they interact in each period. In the first period, entrepreneurs need financing to set up their firms. Because of the need for monitoring, only lenders are willing to provide them with capital. Lenders behave competitively in funding each project, but once a lender is matched with an entrepreneur, they stay together until the last period. If lenders do not have enough capital, they can issue securities, which only traders will choose to buy since only they can ensure that the securities have proper backing. Investors deposit funds with traders. I assume that $K + D + E < WF$, so that all funds of all agents, including the investors, are required to set up all the projects.

In the second period, entrepreneurs require more capital and obtain it from their line of credit with their lender. The lender may issue more securities, and traders can again choose to buy them. In this period, however, investors can also buy the preexisting securities, because lenders and traders have signaled, by trading them in the first period, that these securities are properly backed. However, investors cannot distinguish the securities backed by assets with $A_i' = a$, from those with $A_i' = 0$. Therefore, as long as $Q' > 1 - \varphi$, they will refrain from buying securities directly in this market. Lenders and traders, on the other hand, can distinguish between the two types of securities, so if investors stay out, the price of the $A_i' = 0$ securities is zero, and Q' refers to the price of the $A_i' = a$ securities.

Finally, in the third period, entrepreneurs obtain the revenue from sales, pay the last-period workers, and pay back the lenders. The lenders in turn use part of the proceeds to repay the holders of securities backed by the loans, and traders return the funds belonging to investors. In the end, all agents return their capital to the representative household. All of these financial market participants are risk-neutral and aim to maximize their last-period payoff.

Figure 4 summarizes the timing and the flows of funds just described. I assume that there is enough liquidity to sustain the social optimum, where all projects get funded and marginal costs depend only on wages and productivity, which is equivalent to assuming that total capital H exceeds the setup and up-front labor costs at the efficient level. The problem I focus on here is the allocation of this liquidity, in the presence of the frictions captured by the parameters δ, φ, and μ.

[figure 4 about here]

II.C. Closing the Model

To close the model, I need a few more ingredients, which are spelled out in more detail in the appendix. The first is the demand for each variety of good, which is isoelastic: $Y_i^{''} = C^{''} P_i^{''m/(1-m)}$, where $C^{''}$ is total final consumption, and $P_i^{''}$ is the price of the good. The lender and the entrepreneur jointly decide the optimal scale of production for the productive firms in the second and third periods so as to maximize joint returns:

(2)
$$\max_{P_i^{''}, Y_i^{''}, L_i^{'}, L_i^{''}} \left\{ P_i^{''} Y_i^{''} - W L_i^{''} - W L_i^{'} / Q^{'} \right\},$$

subject to the production function in equation 1 and demand for the good. The optimality condition is

(3)
$$P_i^{''} = m \left(1 - v + \frac{v}{Q^{'}} \right) \left(\frac{W}{a} \right),$$

together with $L^{'} = v(L^{'} + L^{''})$. I assume that $m \in [1, 2]$, so that markups are between 0 and 100 percent, and that $(1 - \delta)m > 1$, so that the pledgeable profits to lenders are positive.

In a symmetric equilibrium, the production of all firms is the same and equal to Y. Total consumption is then $C = N^m Y$, which is increasing in the number of goods produced because variety is valued. Moreover, all prices are the same in equilibrium, which, since consumption goods and capital have the same price, implies that $N^{1-m} P_i^{''} = 1$, so the static cost-of-living price index is constant. Finally, the labor supply function is $C^{''} = W$, which follows from assuming log preferences over consumption and linear disutility of labor supply.

Combining all of these equations provides the solution for the following endogenous variables: total employment in the second and third periods, wages, and the pledgeable amount of operating profits:

(4) $$L' + L'' = \frac{1}{m\left(1-v+v/Q'\right)(1-\varphi)I}$$

(5) $$W = \frac{a\left[(1-\varphi)I\right]^{m-1}}{m\left(1-v+v/Q'\right)}$$

$$\pi_i(Q', I) \equiv (1-\delta)P_i''Y_i'' - WL_i'' - WL_i'/Q'$$

(6) $$= \frac{\left[(1-\delta)m-1\right]a}{m^2\left(1-v+v/Q'\right)\left[(1-\varphi)I\right]^{2-m}}$$

II.D. The Equilibrium Conditions in the Financial Markets

Two restrictions on prices must hold so that there are no arbitrage opportunities that would allow for infinite profits. First, since a security bought in the first period for price Q will, with probability $1 - \varphi$, be worth Q' in the second period, but zero otherwise, and since lenders can sell it in the first period and buy it back in the second period, it must be that $Q \leq (1 - \varphi)Q'$. Otherwise, lenders would make infinite expected profits.[18] Second, and similarly, because lenders can hold cash between the second and the third period with a guaranteed return of 1, it must be that $Q' \leq 1$.

I now characterize the equilibrium securities price and investment in the first period. In the securities market in the first period, if $Q < (1 - \varphi)Q'$, traders strictly prefer to buy securities rather than hold cash, and so their total demand is E/μ. If $Q = (1 - \varphi)Q'$, they are indifferent between cash and securities, and so they will be willing to buy any amount of securities below E/μ. Turning to the supply of securities, if $Q < (1 - \varphi)Q'$, it equals total investment minus the capital of the entrepreneurs and the lenders: $WFI - K - D$. If $Q = (1 - \varphi)Q'$, the lender is indifferent between issuing this amount of securities and any higher amount. Equating demand and supply for $Q < (1 - \varphi)Q'$ and substituting for equilibrium wages from equation 5 gives the first-period securities market equilibrium condition (SM):

$$I^m = \left(K + D + \frac{E}{\mu}\right)\left[\frac{m}{a(1-\varphi)^{m-1}F}\right]\left(1 - v + \frac{v}{Q'}\right). \tag{7}$$

In (*I*, *Q*) space this defines a vertical line for *Q* between zero and $(1 - \varphi)Q'$.

The expected profits of lenders in the first period are $Q(1 - \varphi)I\pi(Q', I) - WFI + K$. There is free entry into this sector, so lenders will enter as long as there are available projects, and profits are strictly positive. If *Q* is above a certain level Q^*, then $I = 1$, and lenders earn positive rents in exchange for their monitoring services.[19] If $Q \leq Q^*$, then lenders' profits are driven to zero, so $Q(1 - \varphi)I\pi(Q', I) - WFI + K = 0$. Solving this equation for *I* and replacing for pledgeable profits from equation 6 gives

$$a(1-\varphi)^{m-1} I^m \left(F - \frac{Q\left[(1-\delta)m - 1\right]}{mI}\right) = Km\left(1 - v + \frac{v}{Q'}\right). \tag{8}$$

This is the zero-profits equilibrium condition (ZP), when $Q \leq Q^*$ and investment is below 1. It defines investment implicitly as an increasing function of *Q*. Intuitively, as the price of securities increases, projects become cheaper to finance, so the amount of entrepreneurial capital needed per project falls and more projects are funded.

Turning to the securities market in the second period, if $1 - \varphi < Q' < 1$, the demand comes solely from traders and equals

$$S' = \frac{E'}{\mu} + \left(\frac{1-\mu}{\mu}\right)\left[\frac{(1-\varphi)Q'}{Q} - 1\right]\left(\frac{E}{\mu}\right). \tag{9}$$

Here the first term is the demand from the new capital, and the second is the extra demand from leveraging capital gains. If $Q' = 1$, the trader is indifferent between zero and the amount in equation 9. As Q' falls, the expected capital gain for traders is smaller, and so they have fewer funds with which to demand securities. If Q' falls all the way to $1 - \varphi$, then investors start buying securities directly, satisfying the supply at that price.

The supply of securities comes from lenders who need capital to cover their outstanding credit lines; thus, it equals $(1 - \varphi)IWL' - D'$ if $Q' < 1$. Replacing for the equilibrium labor and wage from equations 4 and 5 gives the supply function for securities in the second period:

$$S' = \frac{va(1-\varphi)^{m-1} I^{m-1}}{m^2\left(1-v+v/Q'\right)^2} - D'. \tag{10}$$

This is increasing in Q', since a higher price of securities implies a lower marginal cost of production and therefore an increase in the scale of each firm. This requires more funds to finance operations, and hence higher credit lines and more securities issued. When $Q' = 1$, the lenders become indifferent between supplying this and any higher amount.

Equations 7 through 10 provide four conditions to determine the four endogenous variables: the equilibrium price of securities in the first and second periods (Q and Q'), the amount of investment in the first period (I), and the scale of operations and funding in the second period (S'). Together these define the equilibrium in this economy.[20] There are three possible equilibria, which I describe next.

II.E. The Three Equilibrium Cases

The first case is the *efficient economy,* where, in spite of the financial frictions, all projects are still funded ($I = 1$), and financing does not add to the marginal cost of firms: $Q' = 1$. One can show that this will be the case if δ, μ, and φ are each below some threshold. Intuitively, if δ is not too high, then the lenders are able to appropriate enough of the entrepreneurs' revenue so that their profits are high enough and they will wish to finance all the projects. If μ is low enough, the friction impeding the flow of funds from investors to traders is not too severe, and so their funds can satiate the market for securities. Finally, if φ is low enough, the expected profits of lenders in the first period are high, inducing full investment, and investors put a high lower bound on the price of securities in the second period.

The second case is the other extreme, that of a *catastrophic economy*, where the price of securities in the second period has fallen to $1 - \varphi$. Investors start buying securities directly, but because they cannot distinguish profitable from unprofitable assets, for each dollar they spend on a worthwhile security, $\varphi/(1 - \varphi)$ dollars buy a worthless security, squandering their funds and destroying resources. This low price of securities implies that the marginal cost of production ($1 - v + v/Q'$) is high, so that each firm will operate at a small, inefficient scale. And as Q falls even lower, below $(1 - \varphi)^2$, the cost of financing to set up projects in the first period becomes very high, and few firms are set up in the first place.

In between these two extremes is the *constrained economy*, depicted in figure 5 As the top panel of figure 5 shows, the equilibrium price of securities and the level of investment in the first period are determined, taking as given the price of securities in the second period. The vertical line is the SM condition in equation 7, and the upward-sloping curve is the ZP condition in equation 8. The bottom panel shows the equilibrium price in the second period and the scale of the projects, taking as given the price and investment from the previous period. The zigzag line depicts the demand function in equation 9, and the curve is the supply function in equation 10. In this economy there is an extensive-margin inefficiency, as $I < 1$ in equilibrium. Traders do not have enough assets, because of either low capital or tight leverage constraints imposed by investors, so the price of securities Q is below Q^*, making the up-front cost of investing too high relative to future revenue. There is also an intensive-margin inefficiency, since $Q' < 1$, and so the marginal costs of production exceed W/a. Operating firms will hire too little labor and produce too little output, because there is too little second-period capital in the hands of traders to satisfy the lenders' residual need for funds.[21]

[figure 5 about here]

Intuitively, for the economy to operate efficiently, investors' capital must reach entrepreneurs either directly from lenders or through the securities market from traders and investors. In the efficient economy, this happens because entrepreneurs have all the capital they need to set up and operate projects. In the constrained economy, leverage constraints on traders are too tight, so that there are insufficient funds in the securities markets in both periods, and the pledgeability constraint and technological risk prevent lenders' capital from being enough. In the catastrophic economy, investors enter the securities market directly, but do so with great waste since they are unable to pick securities. There is severe mispricing and misallocation of capital, as worthless and worthwhile investments face the same marginal cost of capital in an inefficient pooling equilibrium.[22]

To understand better the role of each of the three frictions in the model, consider what happens in equilibrium as each is shut down. First, if all projects are productive ($\varphi = 0$), then there is no "lemons" problem in the securities market. This implies that the knowledge traders use in picking securities is no longer valuable, and investors can buy securities directly from lenders. Since there is no limit to the amount of securities that lenders can issue, and since investors have all the necessary capital to fund all projects and run them efficiently, the only equilibrium is the efficient one. Second, assume that traders can no longer abscond with capital without being detected ($\mu = 0$). In this case investors will be willing to invest all their funds with traders, who in turn will buy all the securities issued by lenders. Again, the unique equilibrium is the efficient case. Finally, if the banks have a perfect monitoring technology, they can reap all of the revenue from projects ($\delta = 0$). Lenders will then be very willing to lend, a condition reflected in figure 5 by Q^* being quite low, making it more likely that the efficient equilibrium obtains. It is still possible, however, that the friction in the leveraging of traders is so strong that they cannot obtain from investors even the small amount of funds required to fund all projects, and so the constrained equilibrium persists if the SM line is to the left of $I = 1$.

III. Interpreting the Federal Reserve's Actions: Credit Policy

In terms of the model just described, the financial events and crisis described in section I.A can be interpreted as a combination of two effects. First, the downgrading of many securities, following downward revisions of the value of the assets backing them, can be interpreted as an increase in φ in the model. Second, the withdrawal of funds from the financial sector and the fears about the solvency of many financial institutions can be interpreted as an increase in μ. Both of these changes can be interpreted as technological changes, or instead as changes in beliefs about the quality of assets. The economy in 2007-09 can then be seen as moving to a constrained equilibrium like that depicted in figure 5, or perhaps even as on the way to the catastrophic equilibrium.

A policymaker would like to intervene to correct this serious misallocation of funds. Credit policy in this economy consists of transferring the capital trapped in investors' hands to other agents, or alternatively, issuing more claims on final output (and correspondingly taxing more consumption in the final period). What the central bank can achieve with these actions depends on what is assumed about its knowledge and skills.

One extreme is the case where the central bank has no special powers beyond those available to private investors. In terms of the model, this translates into the central bank having neither the ability to monitor loans, nor the know-how to pick securities, nor the power to seize more than a share of the traders' assets. In this case any injection of credit by the central bank in the market is equivalent to an increase in the capital of investors *M*. This does not affect any of the equilibrium conditions in the model, since the problem to be solved is not a lack of funds but their misallocation. Worse, if the central bank misguidedly tries to pick securities, invest in traders, or make loans directly to entrepreneurs, the model predicts that its suboptimal behavior will lead to possibly heavy losses, as money is absconded and investments turn sour.

At the other extreme, consider the case where the central bank can become a lender, able to monitor the behavior of borrowers and ensure that the funds it lends are put to good use. Then, by lending the needed funds to entrepreneurs, the policymaker could reach the social optimum, with no intervention by financial firms. This seems unrealistic and indeed results in absurd predictions: if the central bank could lend as effectively as anyone else, why have a financial system at all? Three intermediate cases are both more interesting and more realistic.

III.A. The Central Bank as a Senior Secure Investor

In the first intermediate case, I assume that the central bank has the ability to make loans to financial institutions that are sure to be fully repaid. In the model this maps into the policymaker both being able to distinguish good projects from bad and having some monitoring technology that ensures that lenders repay the central bank out of the revenue from projects before they or the securities holders get paid. In reality this might be achieved by imposing the condition that central bank loans are senior to those of other creditors, or by the central bank using its regulatory power.

In the model a transfer of funds X from the central bank to lenders in the first period raises their initial capital from D to $D + X$, while leaving their profits unchanged as X is returned in the final period.[23] Figure 6 depicts the effect this has on the equilibrium. The SM line in the first period shifts to the right, leading to an increase in investment and a rise in the price of securities. The extensive margin moves closer to the efficient level. These changes in turn lead to an increase in the supply of securities in the second period, since I is higher, so that the amount needed for the credit lines rises, as well as to a decline in demand, since the increase in Q lowers expected capital gains for traders. Therefore, the price of securities in the second period unambiguously falls, raising marginal costs and leading to a worsening of the intensive margin. Second-round effects then follow as the lower Q' lowers the expected profits of lenders, shifting the zero-profit condition to the left and lowering investment, and so on. As a result of the central bank's actions, more firms are in operation, but each at a smaller, inefficient scale.

[figure 6 about here]

For comparison, consider what happens if the first-period loans X are made to traders instead, as also portrayed in figure 6. Their total assets in the first period increase to $E/\mu + X$, which has exactly the same effect on the first-period equilibrium as the transfer of funds to lenders in the previous scenario. However, in the second-period market, the increase in the assets of traders implies that they will have higher capital gains. Because traders mark their equity to market, they now have an extra source of funds with which to demand securities in the second period, so that the demand curve will be to the right of that in the previous case (in the figure this is drawn as unchanged from the initial case). Therefore, the price of second-period securities falls less than it did in that case. This intervention does not give rise to the same intensive-margin inefficiency that the loan to lenders did.

Alternatively, consider the case where the central bank lends to traders or lenders in the second period rather than the first. Examination of the two equilibrium conditions, equations 9 and 10, shows that E'/μ and D' enter symmetrically; it follows that loans to traders and loans to lenders would have an equivalent effect, raising Q' and improving intensive-margin efficiency. At the same time, they would lower investment in the first period (see equation 7) and so worsen the extensive margin.[24] Note that the crucial difference between the first and the second periods in the model is whether the securities are coming due next period or not. The indifference between lending funds to traders and lending them to lenders applies only to the securities that are about to mature; for all other securities, loans to traders are more effective because they affect the traders' equity and leverage in future periods.

The theory therefore suggests that providing funds to traders of new securities is more effective than providing them to lenders. The intuition is that, by accruing capital gains, traders can use increases in their equity to raise their leverage and draw more of the plentiful funds in the hands of investors to where they are needed in the securities markets. For the Federal Reserve, however, it is more natural to extend loans to commercial banks, as this involves little departure from its usual procedures. The creation of the popular 90-day loans under the TAF, which banks can use instead of the overnight loans available in the federal funds market, is an example of directing funds to lenders. Programs such as the TSLF, the

PDCF, and the TALF are closer to the injection of funds into traders that the model recommends.

III.B. The Central Bank as a Buyer of Securities

Next, consider the stricter case where the central bank has the know-how to evaluate securities in the second period, distinguishing those that are associated with profitable firms from those that are worthless. In this case the central bank can use its funds X to buy securities directly, shifting the demand curve in the bottom panel of figure 5 to the right. In the model this is precisely equivalent to lending funds to traders or lenders in the second period, as was just discussed. It is less effective than lending to traders in the first period because it does not draw investors' funds into the market.

The Federal Reserve followed this path for the latter path of 2008 through the CPFF. This agrees with the model's prescriptions, since it has the same effect on the equilibrium as loans to traders, but the latter in reality are likely easier to manage and less risky. Moreover, in practice, once the central bank starts picking which securities to buy, it opens itself to political and lobbying pressures that may prove dangerous.

III.C. The Central Bank as an Equity Investor

Through its public-private partnerships and its capital stakes in banks, the Treasury has become an equity holder in many financial firms. The Federal Reserve has not done so explicitly, although its uncomfortable actions in support of the rescue of Bear Stearns and AIG make it close to being a de facto investor.[25]

In terms of the model, this case differs from the previous one because the purchases of securities by the traders increase not by X but rather by X/μ. That is, with the central bank now taking an equity stake, the new funds can be leveraged up, drawing more capital from investors into the securities market. In terms of the model, this is unambiguously better than providing loans, but only if the central bank can prevent its new partners from absconding with a share μ of the assets.[26] Moreover, in real life it requires that the government behave like a profit-maximizing shareholder in the firms. Both conditions may not be met, and both surely come with some risk.

IV. Interpreting the Federal Reserve's Actions: Quantitative Policy

The large increase in outstanding reserves and in the size of the Federal Reserve's balance sheet can cause worries. If "inflation is always and everywhere a monetary phenomenon," as in Milton Friedman's famous dictum, then the creation of so much money in the past two years might indicate that inflation is to come.

However, there are good reasons, both empirical and theoretical, to be skeptical of the tight link between money and inflation that a strict monetarist stance would suggest. The attempts at money targeting in the United States and the United Kingdom in the early 1980s did not succeed at achieving the target levels, and even though Japan in the 1990s increased reserves on a scale similar to that in the United States recently, deflation persisted. Conventional models of inflation predict that reserves are irrelevant for the setting of interest rates or the control of inflation.[27] This section discusses these theoretical arguments and examines to what extent the crisis may require their modification.

IV.A. A Simple Model of Price-Level Determination

Consider the following model of price-level (P_t) determination with no uncertainty:

(11) $$(1+i_t)P_t / P_{t+1} = C_{t+1} / \beta C_t$$

(12) $$M_t / P_t = L(i_t - i_t^m, C_t)$$

(13) $$P_t G_t + i_{t-1} B_{t-1} = P_t T_t + V_t + B_t - B_{t-1}$$

(14) $$B_t = B_t^P + B_t^F$$

(15) $$V_t + i_{t-1}^m M_{t-1} + B_t^F - B_{t-1}^F + K_t - K_{t-1} = M_t - M_{t-1} + i_{t-1} B_{t-1}^F + q_{t-1} K_{t-1}$$

(16) $$\ln(1+i_t) = \chi \Delta \ln(P_t) + x_t \, .$$

Equation 11 is the Euler equation for consumption, which equates the real interest rate (the gross nominal rate $1 + i_t$ divided by gross inflation P_{t+1}/P_t) to the discounted change in the marginal utility of consumption, which with log utility equals consumption growth. Equation

12 is the demand for real reserves (M_t/P_t). It depends negatively on the opportunity cost of holding reserves instead of bonds, which is the difference in the interest rates paid on the two assets ($i_t - i_t^m$). When this difference is zero and the other determinants of the demand for reserves are held fixed, the private sector is indifferent toward holding any amount of reserves above some satiation level.[28]

The next two equations refer to the behavior of the Treasury. Equation 13 is the government budget constraint. On the left-hand side are government spending (G_t) and interest payments on outstanding bonds (B_t). On the right-hand side are revenue from taxes (T_t), transfers from the Federal Reserve (V_t), and issuances of new debt. Equation 14 is the market clearing condition for government debt, which may be held either by the Federal Reserve (B_t^F) or by private agents (B_t^P).

The final two equations apply to the central bank. It makes transfers to the Treasury, pays interest on reserves, and buys either government securities or private assets (K_t). These uses of funds are financed by issuing new reserves and by the interest collected on the government bonds and on the portfolio of private securities with return q_t. The last equation is the policy rule for the interest rate, with $\chi > 1$ and policy choices x_t.[29]

To focus on the price level, I take consumption as exogenous, and to focus on monetary policy, I treat government spending as also exogenous. The Federal Reserve's policy is captured by its interest rate policy (its choices of interest rates $\{x_t, i_t, i_t^m\}$), its quantitative policy (its choices regarding the amount of reserves and transfers to the Treasury $\{M_t, V_t\}$), and its credit policy (its choices regarding what assets $\{B_t^F, K_t\}$ to hold). The Treasury's policy is captured by its choices regarding taxation and debt issuance $\{T_t, B_t\}$.[30] The goal is to determine the price level P_t as a function of these nine policy variables, subject to the six equations above and a set of initial and terminal conditions.[31] A policy regime can be defined as a choice of which of these policy variables will be exogenously chosen and which must be accommodated endogenously.

IV.B. The Precrisis Policy Regime

For most of the last 20 years, the press releases and commentary following meetings of the FOMC have focused on the current choice of innovations to the short-term interest rate x_t, and its likely future path. Combining equations 11 and 16 and solving forward, the unique bounded solution for the price level is

$$\Delta \ln(P_t) = \frac{\ln(\beta)}{1-\chi} + \sum_{j=0}^{\infty} \chi^{-j-1} \left[\Delta \ln(C_{t+1+j}) - x_{t+1+j}\right] \tag{17}$$

Regardless of any other policy choice, interest rate policy alone determines inflation. As long as the other policy choices respect the constraints imposed by the equilibrium in equations 11 through 16, understanding and forecasting inflation involves focusing solely on the target rates announced by the FOMC. However the other variables are determined, it is the federal funds rate that determines inflation, according to the model.

Turning to the other variables, the policy rule in equation 16 determines endogenously the observed short-term interest rate i_t. The other exogenous interest rate is i_t^m, the interest rate on reserves, which before October 2008 was zero. The money demand equation (equation 12) then implied that total reserves M_t were determined endogenously. Therefore, there was no independent quantitative policy, as the size of the Federal Reserve's balance sheet had to accommodate the fluctuations in the demand for reserves.

As for credit policy, before 2007 the Federal Reserve chose to hold almost no private securities ($K_t \approx 0$) and to hold government bonds roughly in line with the amount of reserves in circulation ($B_t^F \approx M_t$). The Federal Reserve's budget constraint, equation 15, reduces to

$$V_t \approx i_{t-1} M_{t-1} \tag{18}$$

in steady state. With these policy choices, the Federal Reserve obtained net income from seigniorage every period, rebating almost all of it to the Treasury to keep its accounting capital roughly constant.

Finally, turning to fiscal policy, combining the result in equation 18 with the Treasury's budget constraint in equation 13, the market clearing condition for bonds in equation 14, and the transversality conditions gives

$$B_t^P = P_t(G_t - T_t) + (1 + i_{t-1})B_{t-1}^P - \Delta M_t, \tag{19}$$

$$\sum_{j=0}^{\infty} \left[\frac{P_{t+j}\left(T_{t+j} - G_{t+j}\right) + \Delta M_{t+j}}{\prod_{k=0}^{j}\left(1 + i_{t-1+k}\right)} \right] = B_{t-1}^P. \tag{20}$$

The fiscal authorities can choose a path for deficits subject to the intertemporal solvency constraint in equation 20, and the total outstanding U.S. debt evolves endogenously to satisfy equation 19.

Monetary policy has been independent of fiscal policy in that the Federal Reserve chooses x_t taking only its mandate into account, regardless of the fiscal choices of the Treasury. Fiscal policy is dependent on monetary policy insofar as changes in reserves will affect the flow of seigniorage to the Treasury, but since the term ΔM_{t+j} has in the history of the Federal Reserve been tiny relative to the government's operating balance $P_{t+j}(T_{t+j} - G_{t+j})$, this dependence has been close to irrelevant.

Until recently, both the independence of the central bank to set interest rates and control inflation and the accommodation of reserves to interest rate policy were seen as hallmarks of good monetary policy.[32] Some have even argued that this policy regime partly explains the decline in macroeconomic volatility in the two decades before the crisis.[33]

IV.C. Is the Pre-2007 Status Quo Sustainable?

The crisis has brought significant changes in monetary policy. However, these by themselves do not imply that the determination of the price level must be different from what was just described. According to the model, monetary policy can still independently choose the path for interest rates $\{x_t\}$, and this alone still suffices to determine current and future inflation.

The changes in policy only have to affect variables in the system, other than the inflation. First, because it can now pay interest on reserves, the central bank can choose exogenously either $i_t - i_t^m$ or the quantity of reserves M_t. Unlike before, when the interest rate on reserves was fixed at zero, the central bank may now wish to set a target for the amount of reserves in the market, as long as it adjusts i_t^m accordingly. Moreover, if it continues the current policy of setting $i_t^m = i_t$, the central bank can also target any level of reserves above the satiation level $(M_t/P_t)^*$. This policy has at least two virtues. First, it allows the central bank to inject as much liquidity as necessary to sustain the efficient equilibrium described in the previous section. Second, it eliminates the implicit tax on reserves that existed before 2008 and that Friedman (1960, 1969) and Marvin Goodfriend (2002), among many others, had criticized well before the crisis for being inefficient.

Turning to credit policy, the Federal Reserve can gradually sell its holdings of private securities, receiving in return government bonds until these are again approximately equal to reserves. The only substantial change is that now, with the removal of the implicit tax on reserves, transfers to the Treasury become zero. Since they were small to start with, this should have no visible effect on government finances and fiscal policy. The balance sheet of the Federal Reserve can stay larger than before, with reserves beyond the satiation level at whatever amount is supplied.

The announced intentions of the Federal Reserve are roughly consistent with the scenario just described. The Federal Reserve has been firm in its commitment to set interest rates so as to control inflation and to maintain its independence.[34] Moreover, there is no indication that the decision to pay interest on reserves will be reversed. The Federal Reserve has also indicated that it would like to lower its holdings of private securities to as close to zero as possible as soon as it can.[35]

One source of uncertainty is what the Federal Reserve will do about quantitative policy in the aftermath of the crisis. The Federal Reserve has indicated that once it becomes possible, it will lower reserves and reduce the size of its balance sheet.[36] The theory in this and the previous sections suggests that this is unnecessary, as there is nothing wrong with keeping reserves at high levels. Importantly, this much higher level of reserves is *not* inflationary. Once the Federal Reserve started paying interest on reserves, eliminating the implicit tax on reserves, the old money multiplier that linked reserves to the price level broke down.

IV.D. The Capital and Fiscal Risks to the Status Quo

The main risk to the scenario just described comes from the Federal Reserve's flow of funds in equation 13. Now that interest is being paid on reserves, and now that reserves have more than doubled, the term $i_{t-1}^m M_{t-1}$ can become significant as soon as i_{t-1}^m increases from zero in tandem with the federal funds rate. Moreover, with the Federal Reserve holding a significant amount of private securities, the return on these securities may prove negative, lowering revenue by the amount $q_{t-1}K_{t-1}$.[37] How can the Federal Reserve make up for this budget shortfall?

There are two separate issues, one real and one illusory. To start with the latter, if the Federal Reserve suffers significant losses on its portfolio, its accounting capital may become negative. If the Federal Reserve were an ordinary company, this would mean that it was bankrupt, as its liabilities would exceed its assets. However, the Federal Reserve is *not* an ordinary company, because its liabilities are special. Negative capital is a problem for an ordinary company because it lacks the assets to pay its creditors if they all demand to be paid at once. But the Federal Reserve's two main creditors are currency holders and banks holding reserves. Neither can show up at the central bank and demand to be paid with assets. Currency issued by the Federal Reserve is legal tender, and the holding of reserves can be required by law. This means that there cannot be a run of creditors on the Federal Reserve. Thus, the accounting capital of the Federal Reserve is a vacuous concept. If there is a concern, it is because, as Tiago Berriel and Saroj Bhattarai (2009) document, most central banks, including the Federal Reserve, seem to worry about their capital. As those authors show, if the central bank worries about trying to maintai a target level of capital in its balance sheet, this will move the path of interest rates away from what would be desirable.

The real issue is whether there is a need for outside funds. The Federal Reserve, like any other agent, has a budget constraint. Rearranging equation 13,

(21) $$i^m_{t-1}M_{t-1} - q_{t-1}K_{t-1} = i_{t-1}B^F_{t-1} - (\Delta B^F_t + \Delta K_t) + \Delta M_t - V_t, .$$

The issue is that the left-hand side may become large, requiring additional funds on the right-hand side to maintain equality. The five terms on the right-hand side give the five possible sources of these funds. The first of these is the interest collected on the government bonds the central bank holds. Because $i_{t-1} \geq i_{t-1}^m$, any budget shortfall that arises from paying interest on reserves is at most equal to the interest rate times the difference between reserves outstanding and government securities held. The Federal Reserve's balance sheet on August 19, 2009, reported in table 1, shows that at that date, even if the annual interest rate were as high as 5 percent, this would amount to just over \$10 billion a year.[38] If the Federal Reserve exchanges a few of its private assets for government securities, as it already plans to do by the end of 2009, it can reach the normal state where $B_t^F > M_t$ and the interest on reserves is more than covered by the interest received on government securities.

The danger therefore comes almost entirely from the possibility of large losses on the central bank's holdings of private assets. The second and third terms on the right-hand side of equation 21 show that the Federal Reserve can sell its assets—either the government securities or the private assets—to cover these losses. This cannot go on forever, as the Federal Reserve will eventually run out of assets. But considering the over \$2 trillion in assets that the Federal Reserve holds, this would require quite catastrophic losses for a sustained period.[39]

Another option is to print money or raise reserves, raising M_t. If the economy is already satiated with reserves, this extra printing of money will have no effect on the macroeconomy, as banks will be happy to accept these extra reserves as payment. There is no private or social cost to creating excess and possibly idle reserves.[40]

Only the final option is more troublesome. To pay for its budget shortfall, the Federal Reserve might choose to rely on a steady stream of financing from the Treasury ($V_t < 0$). The financial independence of the Federal Reserve from Congress has been a guarantee of its overall independence.[41] Should transfers from the taxpayer to the Federal Reserve, requiring the approval of Congress, become a regular occurrence, political pressures on the setting of interest rates would become inevitable. There is a real danger that this would lead to permanent increases in inflation in exchange for only short-lived boosts to output, as the U.S. economy falls into the time-inconsistency trap described by Finn Kydland and Edward Prescott (1977).

In the extreme, this loss of independence could even trigger a change in the policy regime. In particular, consider the scenario where Congress limits the fiscal plans of the executive branch by imposing a target for government debt as a ratio to GDP (or consumption): B_t/C_t. The Treasury could accommodate this target by cutting deficits. But it might instead choose a value for nominal deficits exogenously, consistent with an equilibrium.[42] The equilibrium price level would be

$$P_t = \frac{B_t/C_t}{\sum_{j=1}^{\infty} \beta^j (T_{t+j} - G_{t+j})/C_{t+j}} \tag{22}$$

and inflation would be determined solely by the government's fiscal choices. The Federal Reserve would then be forced to accommodate these fiscal policies by effectively handing over control of nominal interest rates, with x_t determined endogenously to satisfy

$$x_t = \Delta \ln (P_{t+1}) - \chi\Delta \ln (P_t) + \Delta \ln (C_{t+1}) - \ln \beta. \tag{23}$$

This fiscalist determination of inflation requires the Treasury to be dominant over the Federal Reserve in setting policy—a situation that the literature has described as the fiscal authorities being active and the central bank passive.[43]

V. Interpreting the Federal Reserve's Actions: Interest Rate Policy

A key feature of the crisis of 2007-09 is that short-term interest rates have been almost zero. This is only the second time that this has happened in the last century in the United States, the other being the period of the Great Depression in the 1930s. Many economists refer to this situation as a "liquidity trap," since zero is the lowest possible target for the federal funds rate, and transitory increases in the money supply lead investors, now indifferent between money and bonds, to simply substitute one for the other. Conventional monetary policy appears powerless.

An extensive literature argues that this appearance is incorrect. Motivated by the experience of the Japan in the 1990s, researchers over the past decade have characterized the challenges in a liquidity trap and offered some policy advice to confront them.[44] They argue that in a liquidity trap, not only is interest rate policy *not* ineffective, but indeed choosing the right path for interest rates becomes particularly important.

To understand this point, recall the Fisher equation equating the real interest rate, r_t, to the nominal interest rate, i_t, minus expected inflation, $E_t(\Delta P_{t+1})$:

$$r_t = i_t - E_t[\Delta \ln (P_{t+1})]. \quad (24)$$

Recall further that the (linearized) Euler equation with log utility for optimal consumption states that expected consumption growth between date t and date $t + s$ is equal to the sum of short-term real interest rates across the two periods:

$$E_t\left[\ln(C_{t+s}) - \ln(C_t)\right] = E_t\left(\sum_{j=0}^{s-1} r_{t+j}\right). \quad (25)$$

Intuitively, the higher is the long-term real interest rate, which is equal to the expected path of short-term real interest rates, the greater the incentive to save, postponing consumption today for consumption in the future.

The challenge for interest rate policy is that the financial crisis and its spillover to the real economy have led to a fall in the real interest rate needed for the economy to respond efficiently. If inflation expectations remain stable and low, equation 24 may imply that the nominal interest rate would have to become negative to generate the needed real interest rate. But because the nominal interest rate has a zero lower bound, this cannot happen, and consequently real interest rates remain too high.[45] Equation 25 then implies that these excessively high real interest rates drive down current consumption, worsening the recession.

The "Brookings answer" to this problem was given in two papers published in this journal. First, Paul Krugman (1998) emphasized that monetary policy is particularly potent in this situation if it can steer inflation expectations. The way out of the trap is to raise inflation expectations by whatever means possible, so that the short-term real interest rate can fall, encouraging consumption. Then, Gauti Eggertsson and Michael Woodford (2003) identified a practical way for the central bank to affect inflation expectations, by committing to keep nominal interest rates low into the future, even after the shocks leading to the crisis have subsided. This would lower expected future short-term real interest rates, producing the fall in long-term real interest rates needed to drive real activity up.

There are several other ways to raise inflation expectations, bring down real interest rates, and stimulate the economy. Devaluing the currency is one, and another is to purchase government debt with a permanent increase in the money supply that is allowed to persist after the crisis has passed. A more institutional approach that would prevent the problem from appearing in the first place would be for the central bank to announce a price-level target, since this would require that current deflation be offset by higher future inflation to get back on target. A final alternative would be for the central bank to commit to lower long-term nominal interest rates, as this would be equivalent to committing to a lower path of short-term rates.[46] It is important to note that these are not alternatives to increasing inflation expectations by committing to low nominal interest rates into the future. Rather, they are different ways to implement the same policy, a decrease in real interest rates, through its relation with other macroeconomic variables..

How do the Federal Reserve's actions compare with these theoretical suggestions? Although the Federal Reserve has not announced a commitment to allow higher inflation than average in the near future, in the way that a price-level target would suggest, it has announced its commitment to do what it can to prevent deflation. The FOMC announcements following every meeting so far in 2009 have stated the intention to keep the target for the federal funds rate at zero for an extended period. These are signs that the advice of Krugman, Eggertsson, and Woodford is being followed, but only halfway, as the Federal Reserve has also signaled that it will not tolerate either temporary or permanent above-normal inflation.[47]

Meanwhile the Federal Reserve has made no commitment to any of the other alternatives. First, announcing a devaluation of the dollar is not an option, since this is the domain of the Treasury, not the Federal Reserve. Second, there has been little purchasing of government debt: the dollar value of Treasury-issued securities plus agency debt held by the Federal Reserve in August 2009, at $847.9 billion, was not dramatically greater than the $778.9 billion it held in January 2007. Although the Federal Reserve has announced that it will expand its purchases of government bonds substantially in the coming months, it has also indicated that this might be temporary, as it returns to a balance sheet similar in size to that in the past once the crisis subsides. Third, the change in the maturity composition of these securities toward longer-term bonds is consistent with an effort to lower long-term interest rates, but there is little evidence that this portfolio shift can have any effect beyond what the announcement of lower future short-term interest rates will achieve.

A crucial part of the Federal Reserve's policy is its future actions, after the crisis subsides, and these remain to be seen. In particular, the FOMC has not clearly stated that it will keep interest rates at zero even after the financial shock disappears, an important component of optimal policy according to the theory just discussed.

VI. Conclusion

This paper has provided a critical analysis of the Federal Reserve's policy actions of the past two years. It has catalogued monetary policy into three types according to whether it affects interest rates, the size of the Federal Reserve's balance sheet, or the allocation of its credit across different assets.

With regard to interest rate policy, the Federal Reserve has followed the advice derived from theory by committing to fight deflation and to keep nominal interest rates at zero for the foreseeable future. It has deviated from the theoretical recommendations by not committing to higher-than-average inflation in the future, and especially by not providing a clear signal that it will keep nominal interest rates low for some time even after the crisis is over.

With regard to quantitative policy, at least theoretically there is no reason why the path of short-term nominal interest rates should stop determining inflation, or why the conventional separation between monetary and fiscal policy should have to be revisited. Both of these features have been lauded as hallmarks of the success of monetary policy in the past two decades. However, the combination of an expansion in the Federal Reserve's balance sheet, the introduction of interest payments on reserves, and the holding by the Federal Reserve of assets with risky returns does pose a danger. The Federal Reserve might face significant budget shortfalls, and overreacting to these may lead to the central bank surrendering its independence from fiscal policy, potentially compromising both of the hallmarks above.

Finally, regarding credit policy, the paper has introduced a new model of how the financial market allocates funds to investment and of the credit frictions in that process. I have considered the merits of different interventions as indicated by the model, conditioned on alternative beliefs about the knowledge and power of the Federal Reserve. The model suggests that using senior loans to inject funds into firms that trade asset-backed securities can restore liquidity in all financial markets. Theoretically, the size of the required government intervention is smaller with this policy than if instead policymakers lend funds to the originators of loans or buy securities directly, and may be more robust than taking equity stakes in financial firms. The Federal Reserve's actions over the past two years have included almost all of these alternatives. Perhaps this was wise, since so little is known in this area. What is more likely is that looking back in a few years and using either the model in this paper or others that will follow, some of the Federal Reserve's credit policies will be seen as ineffective or even harmful.

Although the paper has touched on many different topics, models, and policies, I have not addressed every facet of the crisis or of the role of monetary policy during a crisis. For example, I have considered neither aggregate risk and changes in risk spreads nor the potential for bank runs.[48] Nor have I discussed the role of foreign investors and the external deficit, or compared the Federal Reserve's actions with those of other central banks around the world. Finally, I have not emphasized the political economy trade-offs that the different policies involve, which may become important in the near future.

This interpretation of the Federal Reserve's actions has thus enjoyed the privileges of being selective in the choice of topics and of having some hindsight in addressing them. Neither was available to the Federal Reserve and other central banks in the past two years. Moreover, as is almost always the case when an academic writes about policy, the tone and spirit of this interpretation are based implicitly on the premise that theory runs ahead of practice. The events of the past two years have been humbling on that score, providing a lesson to academics like me that we must be less confident about this premise than usual.

APPENDIX

Details of the Model

This appendix complements the setup and solution of the model described in the text.

A.1. The Problem of the Representative Consumer-Worker

The consumer-worker in the model faces the following optimization problem:

(A.1) $$\max_{C'',L^S,L^{S'},L^{S''}} \ln(C'') - (L^S + L^{S'} + L^{S''})$$

(A.2) $$s.t.: \int_0^N P_i'' C_i'' + H'' = W(L^S + L^{S'} + L^{S''}) + Payoff,$$

(A.3) $$C'' = \left(\int_0^N C_i''^{1/m} di\right)^m.$$

Expression A.1 gives the consumer-worker's preferences. Utility is logarithmic in total consumption and linear in labor supplied; these functional forms make the algebra easier.

Equation A.2 is the budget constraint. On the left-hand side are the uses of funds in the third period, namely, to purchase the consumption good from the firms and to pay taxes H''. On the right-hand side are the sources of the funds: wages received from labor and income received ("payoff") from the four financial participants in the last period. Because utility is linear in labor supply in all three periods, there is a single wage. Since capital is transferred across periods at zero net return, this is the single intertemporal budget constraint.

Finally, equation A.3 is the Dixit-Stiglitz aggregator mapping the consumption of different varieties onto the final composite goods, with elasticity of substitution $m/(m - 1)$.

The optimality conditions are

(A.4) $$1 = \left(\int_0^N P_i''^{1/(1-m)} di\right)^{1-m},$$

(A.5) $$C_i'' = C'' P_i''^{m/(1-m)},$$

(A.6) $$C'' = W.$$

A.2. The Problem of Agents in the Financial Market

Investors start in period 1 with capital M. Their budget constraints for each period are

(A.7) $$Inv + H_I = M,$$

(A.8) $$Inv' + H_I' + Sec' = H_I,$$

(A.9) $$H_I'' = H_I' + Inv + Inv' + (1-\varphi)Sec' / Q'.$$

In words, in the first period they invest *Inv* in traders and keep H_t in capital. In the second period they invest an additional *Inv'*, buy securities in amount *Sec'*, and keep the remainder H_1' in capital. In the third period they receive back their previous investments from traders at zero net return and receive the payoff of the $1 - \varphi$ securities they bought in the previous period that were productive, ending with total capital H_I''.

Entrepreneurs start with capital *K*. The aggregate budget constraint (summed over all entrepreneurs) in each period is

(A.10) $$WFI + H_E = K + Loan,$$

(A.11) $$WL^{'}N + H_E^{'} = Loan^{'} + H_E,$$

(A.12) $$WL^{''}N + H_E^{''} = \delta P^{''}Y^{''}N + H_E^{'}.$$

In the first period entrepreneurs use their own capital and the loans from lenders to pay their fixed costs, with H_E left over. In the second period they have this capital plus new loans, which they spend on the operating costs of their firms, leaving $H_E{}^{'}$ for the next period. Finally, in the last period, they receive the share δ of revenue and end with total capital $H_E{}^{''}$.

The budget constraints of the lending sector in the aggregate in each period are

(A.13) $$Loan + H_L = D + S,$$

(A.14) $$Loan^{'} + H_L^{'} = D^{'} + S^{'} + Sec^{'} + H_L,$$

(A.15) $$(1-\varphi)S/Q + S^{'}/Q^{'} + (1-\varphi)Sec^{'}/Q^{'} + H_L^{''} = (1-\delta)NP^{''}Y^{''} + H_L^{'}.$$

In the first period lenders start with capital *D* and obtain extra capital *S* by selling securities. They use this to make loans and retain a nonnegative amount of capital H_L. In the next period they receive new capital, sell new securities to traders and investors, and can use this and the capital saved from last period to increase their lending, through the credit lines extended to the entrepreneurs, while potentially holding some capital for the following period. Finally, in the last period, they receive a share 1 – δ of the firms' revenue and must pay back the holders of securities backed by the loans to the surviving firms.

Finally, the aggregate budget constraints of the traders in each period are

(A.16) $$S + H_T = E + Inv,$$

(A.17) $$S^{'} + H_T^{'} = E^{'} + Inv^{'},$$

(A.18) $$Inv + Inv^{'} + H_T^{''} = (1-\varphi)S/Q + S^{'}/Q^{'}.$$

In the first period traders buy securities *S* and hold capital H_T, using their starting funds *E* plus *Inv* received from investors. The same applies in the second period. In the third period the investments are repaid at zero net cost, and the securities earn a nonzero return. The pledgeability constraints on investment are

(A.19) $$Inv \le (1-\mu)S,$$

(A.20) $$Inv^{'} \le (1-\mu)\left\{S^{'} + \left[(1-\varphi)Q^{'} - Q\right]S/Q\right\}.$$

The second term in the pledgeability constraint in the second period is the capital gain on the securities bought in the previous period. The possible absconding of traders with the assets is not included in these constraints, because this never happens in equilibrium.

The capital holdings for all agents are nonnegative: H_I, $H^{'}_I$, $H^{''}_I$, H_E, $H^{'}_E$, $H^{''}_E$, H_L, $H^{'}_L$, $H^{''}_L$, H_T, $H^{'}_T$, $H^{''}_T$ are all greater than or equal to zero.

A.3. Optimality Conditions for Financial Agents

Each of the risk-neutral financial agents wants to maximize its final capital. I focus here on the case where, in equilibrium, there is some inefficiency, so $Q < 1 - \varphi$, and $Q' < 1$. The other cases are similar.

Investors want to maximize H''_I. As long as $Q' < 1 - \varphi$, they will buy no securities, $Sec' = 0$, since doing so leads to a negative return. Moreover, they are indifferent between holding capital and placing it with traders, and I assume that they invest as much as they can, subject to the pledgeability constraint.

Entrepreneurs earn strictly positive profits. Therefore, the return from applying their capital in the firm exceeds that from keeping it idle, and $H_E = H'_E = 0$. The optimal number of projects started and the optimal amount of labor hired are determined in section II.C.

Lenders are willing to sell securities at a positive return to traders, and therefore they must not be holding capital at zero return, so $H_L = H'_L = 0$. The optimal choice of *Loan* and *Loan*$'$ was determined in section II.C, and the optimal issues of S and S' were stated in section II.D and derive from the budget constraints.

Traders earn a positive net return on the securities. Since capital earns a zero return, they choose $H_T = H'_T = 0$. Since they pay zero return to investors, they will want to draw funds from them to the extent possible. The pledgeability constraints therefore hold with equality. Combining the pledgeability and budget constraints gives the demand for securities in the text, $S = E/\mu$ and $S' = E'/\mu + [(1-\mu)/\mu][(1-\varphi)Q'/Q - 1]E/\mu$.

A.4. Market Clearing Conditions and Walras' Law

I start by summing the budget constraints for the four financial agents, to obtain the market clearing conditions for capital within the financial market. This gives

$$H_I = M + K + D + E - WFI \tag{A.21}$$

$$H'_I = H_I + D' + E' - WL'N \tag{A.22}$$

$$H''_I + H''_E + H''_L + H''_T = NP''Y'' - NWL'' + H'_I. \tag{A.23}$$

The first two conditions determine the capital left over with investors at the end of the first two periods. They show that as long as M is large enough, $H_I > 0$ and $H'_I > 0$, an assumption that I maintain throughout the analysis. This in turn translates into an assumption for total initial capital, since the market clearing condition for capital between the representative household and financial institutions in the first period is

$$H = M + K + D + D' + E + E'. \tag{A.24}$$

The payoff from financial firms to households in the last period is

$$Payoff = H''_I + H''_E + H''_B + H''_L \tag{A.25}$$

$$= P''Y''N - WL''N + H'_I \tag{A.26}$$

$$= P''Y''N - WL''N - WL'N - WFI + H \quad , \tag{A.27}$$

where the second equation comes from the market clearing condition for capital in the third period, and the third from using the market clearing conditions in the other periods. Noting that market clearing in the goods market implies that $\int_0^N P_i''C_i''di = P''Y''N$, and therefore this last expression can be rewritten as

(A.28) $$\int_0^N P_i'' C_i'' + H = WFI + WL'N + WL''N + Payoff\,.$$

Finally, since the labor market clearing conditions are $FI = L^S$, $L'N = L^{S'}$, and $L''N = L^{S''}$, this expression becomes the budget constraint of the representative consumer. This verifies Walras' law and confirms that all funds have been accounted for.

References

Allen, Franklin, Ana Babus, and Elena Carletti. 2009. "Financial Crises: Theory and Evidence." *Annual Review of Financial Economics*, Vol. 1, forthcoming..

Auerbach, Alan J., and Maurice Obstfeld. 2005. "The Case for Open-Market Purchases in a Liquidity Trap." *American Economic Review* 95, no.1: 110-37.

Bassetto, Marco. 2008. "Fiscal Theory of the Price Level." In *The New Palgrave Dictionary of Economics*, edited by Lawrence E. Blume and Steven N. Durlauf. London: MacMillan.

Bernanke, Ben S. 2002. "Deflation: Making Sure 'It' Doesn't Happen Here." Remarks at a meeting of the National Economists Club, Washington**,** November 21.

Berriel, Tiago C., and Saroj Bhattarai. 2009. "Monetary Policy and Central Bank Balance Sheet Concerns." *B.E. Journal of Macroeconomics* (Contributions) 9, no. 1.

Blanchard, Olivier. 2009. "The Crisis: Basic Mechanisms, and Appropriate Policies." *CESifo Forum* Vol. 10, no. 1

Brunnermeier, Markus K. 2009. "Deciphering the Liquidity and Credit Crunch 2007-2008." *Journal of Economic Perspectives* 23, no.1: 77-100.

Buiter, Willem H., and Nikolaos Panigirtzoglou. 2003. "Overcoming the Zero Bound on Nominal Interest Rates with Negative Interest on Currency: Gesell's Solution." *Economic Journal* 113, no.490: 723-46.

Canzoneri, Matthew B., Robert E. Cumby, and Behzad T. Diba. 2001. "Is the Price Level Determined by the Needs of Fiscal Solvency?" *American Economic Review* 91, no.5: 1221-38.

Cecchetti, Stephen G. 2009. "Crisis and Responses: The Federal Reserve in the Early Stages of the Financial Crisis." *Journal of Economic Perspectives* 23, no.1: 51-75.

Cochrane, John H. 2009. "Understanding Fiscal and Monetary Policy in 2008-2009" University of Chicago.

Cukierman, Alex. 2008. "Central Bank Independence and Monetary Policymaking Institutions: Past, Present and Future." *European Journal of Political Economy* 24, no. 4: 722-36.

Cúrdia, Vasco, and Michael Woodford. 2009. "Conventional and Unconventional Monetary Policy." Columbia University.

Eggertsson, Gauti B., and Michael Woodford. 2003. "The Zero Bound on Interest Rates and Optimal Monetary Policy." *BPEA*, no. 1: 139-211.

Friedman, Milton. 1960. *A Program for Monetary Stability.* Fordham University Press.

_________. 1969. *The Optimum Quantity of Money: and Other Essays.* Aldine.

Goodfriend, Marvin. 2000. "Overcoming the Zero Bound on Interest Rate Policy." *Journal of Money*, *Credit*, *and Banking* 32, no. 4: 1007-35.

_________. 2002. "Interest on Reserves and Monetary Policy." *Economic Policy Review* 8, no. 1: 77-84.

Gorton, Gary. 2009. "Information, Liquidity, and the (Ongoing) Panic of 2007." *American Economic Review* 99, no. 2: 567-72.

Greenlaw, David, Jan Hatzius, Anil K Kashyap, and Hyun Song Shin, eds. 2008. *Leveraged Losses: Lessons from the Mortgage Market Meltdown: Proceedings of the U.S. Monetary Policy Forum*. Rosenberg Institute, Brandeis International Business School, and Initiative on Global Markets, University of Chicago Graduate School of Business.

Holmström, Bengt, and Jean Tirole. 2009. *Inside and Outside Liquidity. Wicksell Lectures*. In preparation.

Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Cycles." *Journal of Political Economy* 105, no. 2: 211-48.

Krishnamurthy, Arvind. Forthcoming. "Amplification Mechanisms in Liquidity Crises." *American Economic Journal: Macroeconomics*.

Krugman, Paul R. 1998. "It's Baaack: Japan's Slump and the Return of the Liquidity Trap." *BPEA*, no. 2**:** 137-187.

Kydland, Finn E., and Edward C. Prescott. 1977. "Rules Rather Than Discretion: The Inconsistency of Optimal Plans." *Journal of Political Economy* 85, no. 3: 473-91.

Matsuyama, Kiminori. 2007. "Aggregate Implications of Credit Market Imperfections." Working Paper no. 13209. Cambridge, Mass.: National Bureau of Economic Research.

Mishkin, Frederic S. 2007. *Monetary Policy Strategy*. MIT Press.

Reis, Ricardo. 2007. "The Analytics of Monetary Non-Neutrality in the Sidrauski Model." *Economics Letters* 94, no. 1: 129-35.

__________. 2009. "Where Should Liquidity Be Injected during a Financial Crisis?" Columbia University.

Romer, Christina D. 1992. "What Ended the Great Depression?" *Journal of Economic History* 52, no. 4: 757-84.

Shleifer, Andrei, and Robert W. Vishny. 2009. "Unstable Banking." Working Paper no. 14943. Cambridge, Mass.: National Bureau of Economic Research.

Sims, Christopher A. 1994. "A Simple Model for Study of the Determination of the Price Level and the Interaction of Monetary and Fiscal Policy." *Economic Theory* 4, no.3: 381-99.

__________. 2009. "Price Level Determination in General Equilibrium." Presented at the annual meeting of the Society for Economic Dynamics, Istanbul, July 2-4.

Stella, Peter. 2009. "The Federal Reserve System Balance Sheet: What Happened and Why It Matters." IMF Working Papers. Washington: International Monetary Fund.

Svensson, Lars E. O. 2003. "Escaping from a Liquidity Trap and Deflation: The Foolproof Way and Others." *Journal of Economic Perspectives* 17, no. 4: 145-66.

Woodford, Michael. 1995. "Price-Level Determinacy without Control of a Monetary Aggregate." *Carnegie-Rochester Conference Series on Public Policy* 43: 1-46.

__________. 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton University Press.

__________. 2008. "How Important Is Money in the Conduct of Monetary Policy?" *Journal of Money, Credit and Banking* 40, no. 8: 1561-98.

[1]Operating procedures for the discount window changed in January 2003, and therefore a consistent discount rate series for the whole period does not exist. For the federal funds rate in 2009, I plot the upper end of the range targeted by the Federal Reserve. The figure also shows the interest rate on reserves that was introduced in October 2008, discussed further below.

[2]U.S. Treasury bills are three-month securities; total Treasury securities include bonds and notes, which have longer maturities. The figure includes only securities held outright, not those held as part of repurchase agreements.

[3]The model is a simple version of the more complete analysis in Reis (2009).

[4]See Brunnermeier (2009), Gorton (2009), and Greenlaw and others (2008).

[5]The situation at the time looked so dire that the head of the International Monetary Fund, Dominique Strauss-Kahn, stated apocalyptically on October 11 that, "Intensifying solvency concerns about a number of the largest U.S.-based and European financial institutions have pushed the global financial system to the brink of systemic meltdown" ("Statement by the IMF Managing Director, Dominique Strauss-Kahn, to the International Monetary and Financial Committee on the Global Economy and Financial Markets, Washington, October 11").

[6]For alternative descriptions of the policy responses to the crisis, see Cecchetti (2009) for the United States and Blanchard (2009) for an international perspective, as well as the many speeches by governors of the Federal Reserve available on its "News & Events" page (www.federalreserve.gov/newsevents/default.htm). An up-to-date exposition is the Federal Reserve's statement of its "Credit and Liquidity Programs and the Balance Sheet" (www.federalreserve.gov/monetarypolicy/bst.htm).

[7]More precisely, in December 2008 the Federal Reserve started announcing upper and lower limits for this rate, which at that time were 0.25 percent and zero.

[8]The December 2008 press release of the Federal Open Markets Committee (FOMC) stated that, "...the Committee anticipates that weak economic conditions are likely to warrant exceptionally low levels of the federal funds rate for some time." The commitment to low interest rates has been reaffirmed at every meeting since then, with slightly different wording since March 2009.

[9]The Federal Reserve also controls the interest rate that it charges banks that borrow from it directly at the discount window. Although banks rarely use the discount window during normal times, this facility can be important during crises.

[10]For instance, in April 2009 Vice Chairman Donald Kohn stated, "...the Federal Reserve has begun making substantial purchases of longer-term securities in order to support market functioning and reduce interest rates in the mortgage and private credit markets" ("Policies to Bring Us Out of the Financial Crisis and Recession," speech delivered at the College of Wooster, Wooster, Ohio, April 3, 2009). Chairman Ben Bernanke stated that, "The principal goal of these programs is to lower the cost and improve the availability of credit for households and businesses" ("The Federal Reserve's Balance Sheet," speech delivered at the Federal Reserve Bank of Richmond 2009 Credit Markets Symposium, Charlotte, N.C., April 3, 2009).

[11]These included the Term Auction Facility (TAF), the Term Securities Lending Facility (TSLF), the Primary Dealer Credit Facility (PDCF), the Commercial Paper Funding Facility (CPFF), the Term Asset-Backed Securities Loan Facility (TALF), the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), and the Money Market Investor Funding Facility (MMIFF).

[12]The Federal Reserve also made funds available to lend to the money market, through the MMIFF for money market funds, and through the AMLF programs for banks to finance purchases from money market funds. The first program was never used; the funds under the AMLF are included in the "direct loans" item on the balance sheet, but the balance is currently zero.

[13]A few notes are in order regarding this capital. First, it is a very crude way to introduce an asset in this economy that is used as a means of payment. However, it allows me to keep the focus on the credit frictions and to avoid having to describe in detail the underlying theory of money or assets. Second, although I assume that, like money, capital pays a zero net return, generalizing the model to include a positive return does not change the results qualitatively. Third, I use the term "capital" and

not “money” because these assets can be thought of as broader than just high-powered money. They represent any claims that can be exchanged for consumption goods in the last period, and so they refer to all assets in this economy. Fourth, these assets could be private claims issued by the representative consumer, if the consumer could commit to their repayment, thus dispensing with the need for a government or taxes. However, decentralizing this economy to justify the existence of the representative consumer is a difficult task. Fifth, an alternative would be to assume that *H* is a physical good that can be stored without depreciating and can be transformed into the final consumption good in the final period. This leads to predictions similar to those in this paper, but messier algebra.

[14]This limited pledgeability constraint has a long tradition in the modeling of capital market imperfections: see Matsuyama (2007) and Holmstrom and Tirole (2009) for recent reviews. Note that one can reinterpret the *F* setup costs as the cost to lenders to set up the monitoring technology to which only they have access, allowing them to capture 1-δ of the revenue.

[15]Note that *S* is the total revenue from selling the security in the first period, so that *S/Q* is the number of securities sold paying this amount of capital in the third period. The same applies to S'.

[16] I assume that even if traders abscond with the securities, they can show up to redeem them in the last period.

[17]Lenders cannot obtain direct financing from investors, since in equilibrium their assets will consist solely of the outstanding loans. Only lenders can monitor these loans, so seizing the lenders’ assets would produce zero revenue.

[18]The fact that capital gains on a portfolio of securities are always nonnegative is a consequence of the lack of aggregate uncertainty. It is straightforward to extend the model to include uncertainty; since all agents are risk-neutral, this would change little in the analysis after replacing expected for actual values.

[19]Q^* is defined as $Q^* = \dfrac{WF-K}{(1-\varphi)\pi(Q',1)}$.

[20]With these four variables determined, equilibrium wages and hours worked are determined by equations 4 and 5. Equilibrium output and consumption follow from using the production function and the market clearing condition in the goods market.

[21]One can see that the efficient equilibrium in this graph would require that the SM line lie to the right of I = 1 so that, in the second period, demand and supply would coincide over a line segment in the region at the top where they are horizontal. The catastrophic equilibrium occurs when the supply curve intersects the demand curve in its lower horizontal segment.

[22]One feature of this model, as well as of most models of credit frictions, is that there is too little borrowing. Some have argued that the current crisis is due rather to too much borrowing, but to my knowledge this has not yet been formalized.

[23]This assumes that the central bank is not trying to profit from the loan, so that the net interest rate it charges is zero.

[24]Leaving the constrained equilibrium and reaching the efficient one would require large loans in either or both periods. If that is not possible, then a well-calibrated increase in the funds available to traders in both periods could simultaneously improve both extensive- and intensive-margin efficiency.

[25]The Federal Reserve’s discomfort with these actions is clear in Chairman Bernanke’s speech of April 3, 2009, cited above: “[The purchases covered by Maiden LLC] are very different than the other liquidity programs discussed previously and were put in place to avoid major disruptions in financial markets. From a credit perspective, these support facilities carry more risk than traditional central bank liquidity support, but we nevertheless expect to be fully repaid .… These operations have been extremely uncomfortable for the Federal Reserve to undertake and were carried out only because no reasonable alternative was available.”

[26]In reality, agents receiving the funds need not literally abscond with them. They may instead pick dishonest partners, exert too little effort, or divert company investments toward private gains.

[27]See Woodford (2008), among many others.

[28]One assumption implicit in these two equations is that real money balances do not affect the

marginal utility of consumption. Although deviations from this strict separability assumption can have strong theoretical implications for monetary policy (Reis 2007), empirically the deviations seem small (see section 3.4 in Woodford 2003).

[29]Adding a real activity variable to bring this rule close to a Taylor rule would change nothing in the analysis.

[30]In the world outside the model, this sharp distinction between fiscal and monetary policy has become blurred by the recent cooperation between the Federal Reserve and the Treausry in addressing the crisis.

[31]The initial conditions are $M_{t\text{-}1}$, $B_{t\text{-}1}^{F}$, $B_{t\text{-}1,}$ $K_{t\text{-}1}$, and the terminal conditions come from consumer optimization with no outside assets and nonnegative holdings of money and bonds: $\lim_{j\to\infty}\beta^j u'(C_{t+j})B_{t+j}^{P}/P_{t+j} = 0$ and $\lim_{j\to\infty}\beta^j u'(C_{t+j})M_{t+j}/P_{t+j} = 0$.

[32]See Woodford (2003) and Mishkin (2009).

[33]See, for instance, Chairman Bernanke's speech on "The Great Moderation," delivered at the Eastern Economic Association, Washington, February 20, 2004.

[34]From the joint statement of the Federal Reserve and the Treasury on March 23, 2009: "The Federal Open Market Committee (FOMC) determines monetary conditions in the United States, subject to its congressional mandate to foster maximum sustainable employment and stable prices. The Federal Reserve's independence with regard to monetary policy is critical for ensuring that monetary policy decisions are made with regard only to the long-term economic welfare of the nation." From the same statement: "Actions that the Federal Reserve takes, during this period of unusual and exigent circumstances, in the pursuit of financial stability, such as loans or securities purchases that influence the size of its balance sheet, must not constrain the exercise of monetary policy as needed to foster maximum sustainable employment and price stability."

[35]As Vice Chairman Kohn put it in a speech in May 2009, "An important issue with our nontraditional policies is the transition back to a more normal stance and operations of monetary policy as financial conditions improve and economic activity picks up enough to increase resource utilization. These actions will be critical to ensuring price stability as the real economy returns to normal" ("Interactions between Monetary and Fiscal Policy in the Current Situation," speech delivered at Princeton University, May 23, 2009).

[36]As Chairman Bernanke stated in his April 3 speech, cited above, "We have a number of tools we can use to reduce bank reserves or increase short-term interest rates when that becomes necessary.… Many of our lending programs extend credit primarily on a short-term basis and thus could be wound down relatively quickly.… The Federal Reserve can conduct reverse repurchase agreements against its long-term securities holdings to drain bank reserves or, if necessary, it could choose to sell some of its securities."

[37]The Federal Reserve has repeatedly stated that it believes the risk of losses is minimal (see, for example, Chairman Bernanke's Stamp Lecture at the London School of Economics, "The Crisis and the Policy Response," January 13, 2009), because in most of its programs it is taking triple-A-rated securities as collateral and imposing significant haircuts. There is reason to be a little skeptical, however. First, if the investments were riskless, one would expect that private investors would not be so reluctant to make them. Second, there is a certain irony in appealing to the high ratings of the collateral when the financial crisis has been marked by suspicions about the value of collateral and the reliability of ratings agencies.

[38]This is calculated by multiplying 0.05 by the sum of bank reserves plus Treasury deposits minus securities held outright. This maps onto the worst-case scenario, where the Treasury closes its deposit account with the Federal Reserve, demanding that its $240.2 billion in bonds be given back. Excluding this possibility, then already $B_t^F > M_t$.

[39]Stella (2009) tries to quantify this risk and arrives at a worst-case scenario of losses of $78 billion on the existing assets (the sum of losses in Table 8 in his paper).

[40]Note that this option relies on the existence of a finite satiation level in the demand for reserves, beyond which people are indifferent about the real money balances they hold. Otherwise, printing money would compromise the Federal Reserve's target for inflation.

[41]Indeed, conventional measures of central bank independence typically consider budgetary independence from the legislative bodies a prerequisite (see the recent survey in Cukierman 2008).
[42]This mechanism is described in Sims (1994) and Woodford (1995) and is discussed and criticized in Canzoneri, Cumby, and Diba (2001) and Bassetto (2008).
[43]For further exploration of the implications of this fiscal theory of the price level within the context of the current crisis, see Sims (2009) and Cochrane (2009).
[44]This work in turn builds on earlier analyses of monetary policy during the Great Depression. Romer (1992), in particular, makes a compelling case for the powerful role of monetary policy in ending the Depression.
[45]The nominal interest rate on any safe security cannot be negative, because selling this security short and keeping the proceeds as cash until the security matures would result in positive profits and create an arbitrage opportunity. This is only approximately correct since the expected return on money is not exactly zero but slightly negative, as deposit accounts pay fees, and cash held in one's pocket may be stolen. Nevertheless, it is likely very close to zero. Goodfriend (2000) and Buiter and Panigirtzoglou (2003) have revived an old proposal by Silvio Gesell for the government to tax money, effectively removing the lower bound on interest rates and therefore eliminating the possibility of liquidity traps.
[46]On exchange rate policy see Svensson (2003), on debt purchases see Auerbach and Obstfeld (2005), on price-level targeting see Eggertsson and Woodford (2003), and on lowering long-term interest rates see Bernanke (2002).
[47]This was clearly stated by Vice Chairman Kohn on October 9, 2009.
[48]On risk spreads, see Cúrdia and Woodford (2009), and on bank runs see Allen, Babus, and Carletti (2009).

Table 1. Balance Sheet of the Federal Reserve, Selected Dates, 2007-09

Billions of dollars

January 3, 2007

Assets		*Liabilities and capital*	
Securities held outright		Federal Reserve notes	781.3
U.S. Treasury bills	277.0	Commercial bank reserves	20.0
U.S. Treasury notes and bonds	501.9	U.S. Treasury deposits	6.2
Agency debt	0	Reverse repurchase agreements	29.7
Repurchase agreements	39.8	Other liabilities	10.6
Direct loans	1.3		
Gold	11.0	Total liabilities	847.9
Foreign reserves	20.5		
Other assets	16.7	Capital	30.6
Total	878.5	Total	878.5
Memorandum: federal funds target rate	5.25%		

December 31, 2008

Assets		*Liabilities and capital*	
Securities held outright		Federal Reserve notes	853.2
U.S. Treasury bills	18.4	Commercial bank reserves	860.0
U.S. Treasury notes and bonds	457.5	U.S. Treasury deposits	365.4
Agency debt	19.7	Reverse repurchase agreements	88.4
Repurchase agreements	80.0	Others	56.8
Direct loans	193.9		
Gold	11.0	Total liabilities	2,223.8
Foreign reserves	579.8		
Other assets	40.3	Capital	42.2
New asset categories			
Term Auction Facility (TAF)	450.2		
Commercial Paper Funding Facility (CPFF)	334.1		
Maiden Lane	73.9		
Total	2,265.9	Total	2,265.9
Memorandum: federal funds target rate	0.0-0.25%		

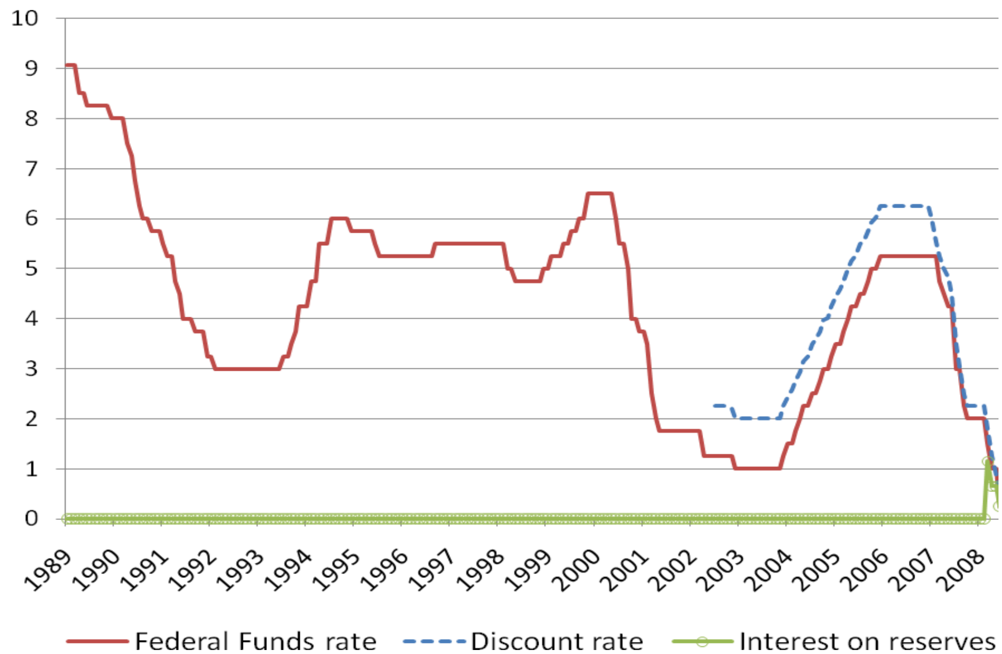
August 19, 2009

Assets		*Liabilities and capital*	
Securities held outright		Federal Reserve notes	871.5
U.S. Treasury bills	18.4	Commercial bank reserves	818.8
U.S. Treasury notes and bonds	717.7	U.S. Treasury deposits	240.2
Agency debt	111.8	Reverse repurchase agreements	68.4
Repurchase agreements	0	Others	14.4
Direct loans	106.3		
Gold	11.0	Total liabilities	2,013.3
Foreign reserves and other assets	76.7		
New asset categories		Capital	50.5
Term Auction Facility (TAF)	221.1		
Commercial Paper Funding Facility (CPFF)	53.7		
Maiden Lane	61.7		
Mortgage-backed securities	609.5		
Central bank liquidity swaps	69.1		
Total	2,063.8	Total	2,063.8
Memorandum: federal funds target rate	0.0-0.25%		

Sources: Board of Governors of the Federal Reserve System, ”Credit and Liquidity Programs and the Balance Sheet,” statistical release H.4.1, “Factors Affecting Reserve Balances,” various issues, and Federal Reserve Bank of New York, “Treasury and Federal Reserve Foreign Exchange Operations,” various issues.

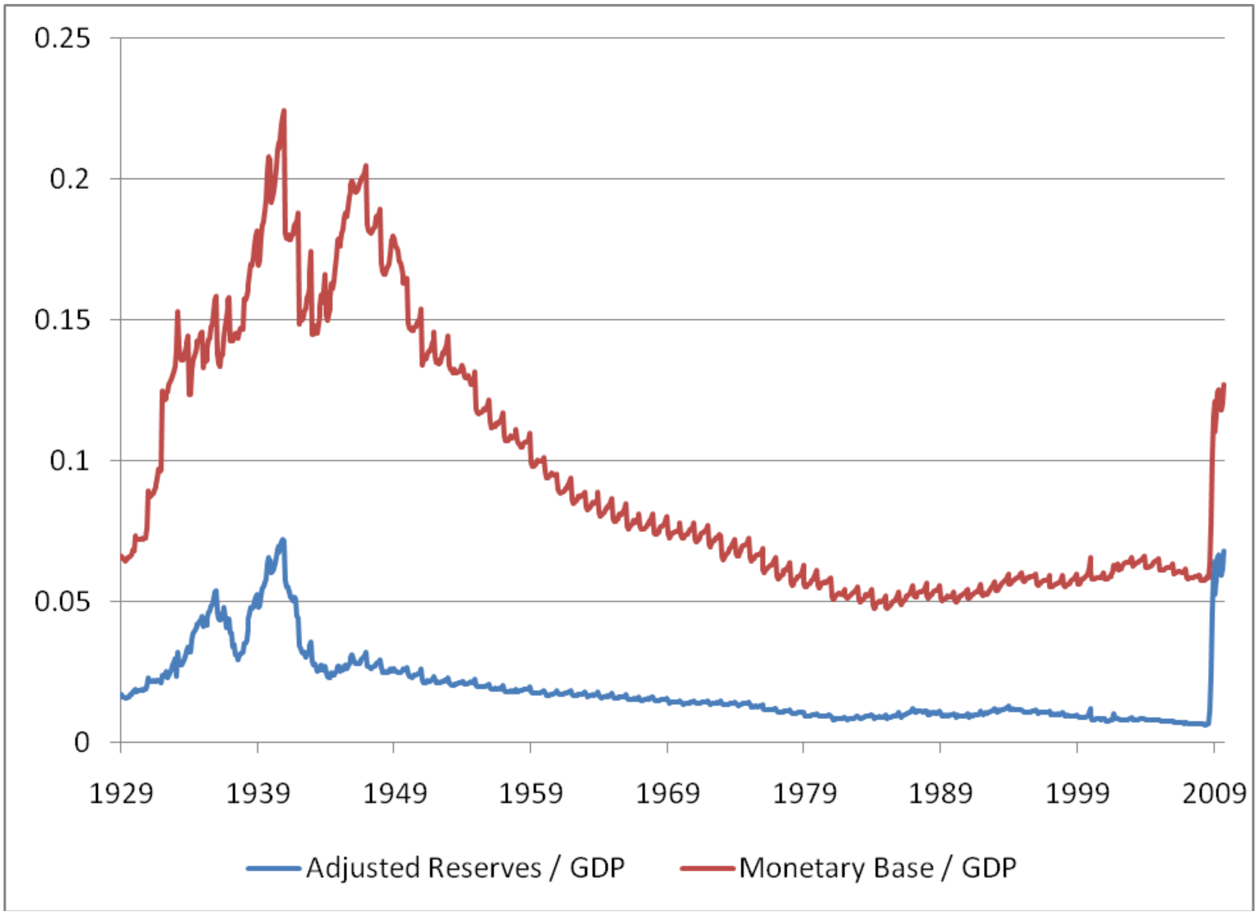
a. Items may not sum to totals because of rounding.

Figure 1. Interest Rates Targeted by the Federal Reserve, August 1989-August 2009



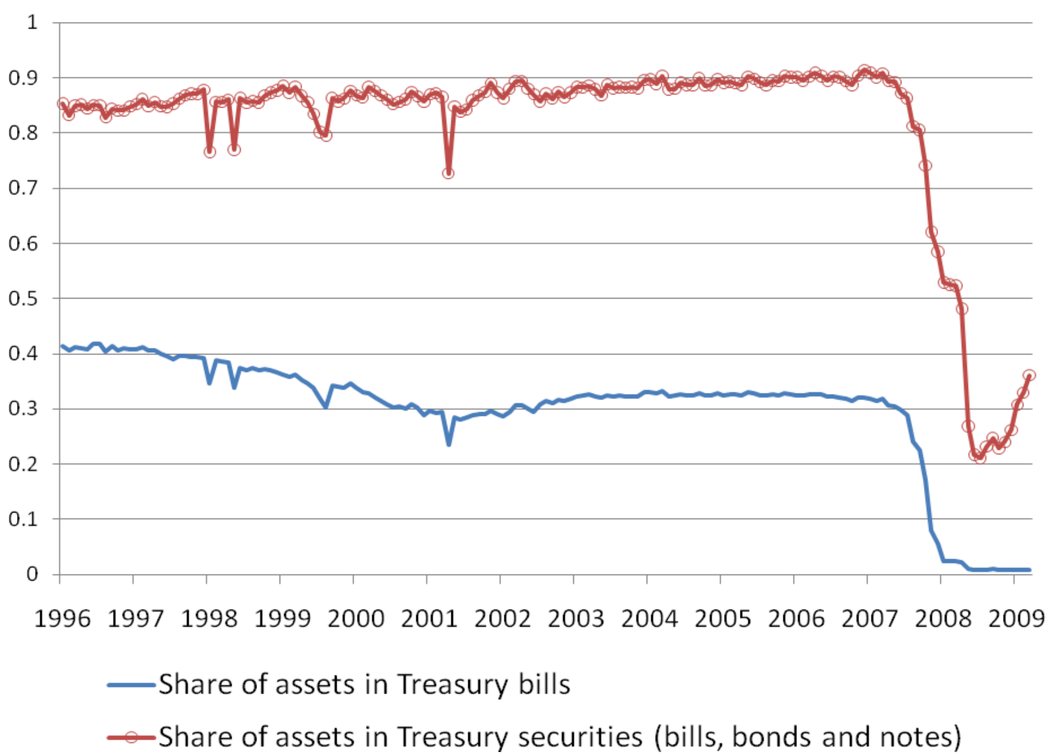
Sources: Federal Open Market Committee press releases; Federal Reserve statistical release H.15, "Selected Interest Rates," various issues; and author's calculations.

Figure 2. Adjusted Reserves and Monetary Base, 1929-2009



Source: Federal Reserve Bank of St. Louis, Federal Reserve Economic Data (FRED).

Figure 3. U.S. Treasury Securities Held Outright by the Federal Reserve, June 1996-August 2009



Sources: Board of Governors of the Federal Reserve System, "Credit and Liquidity Programs and the Balance Sheet," statistical release H.4.1, "Factors Affecting Reserve Balances," various issues.

Figure 4. Flows of Funds and Characterization of Markets in the Credit Frictions Model

Panel A. Timing

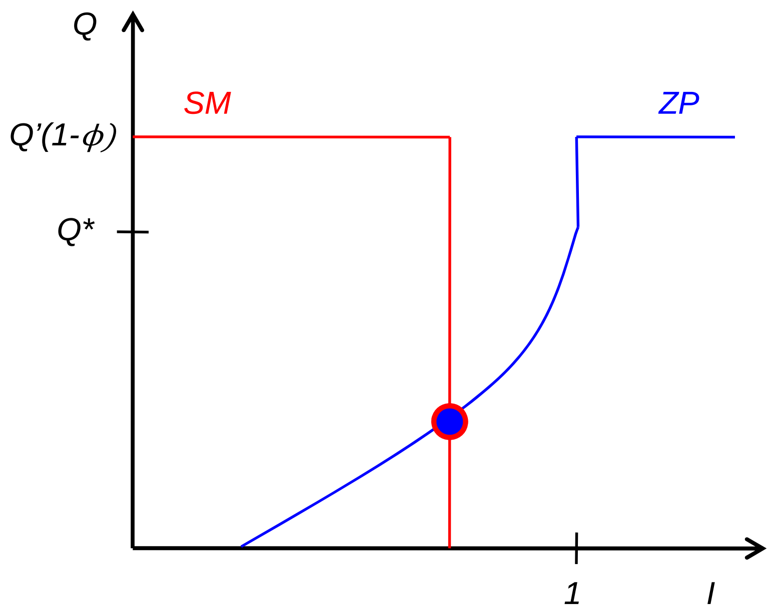
Second period flow of funds:
Lenders -> Entrepreneurs (credit lines)
Traders -> Lenders (securities market)
Investors -> Traders (leverage over capital gains)
Investors -> Lenders (if $Q' = 1 - \phi$)

First period flow of funds:
Lenders -> Entrepreneurs (loan for set-up costs)
Traders -> Lenders (securities market)
Investors -> Traders (leverage)

Third period flow of funds:
Entrepreneurs -> Lenders (loans repaid)
Lenders -> Traders (securities mature)
Lenders -> Investors (securities mature)
Traders -> Investors (leverage repaid)
All agents -> representative household (initial capital and profits)

Panel B. Markets

Figure 5. Equilibrium in a Constrained Economy



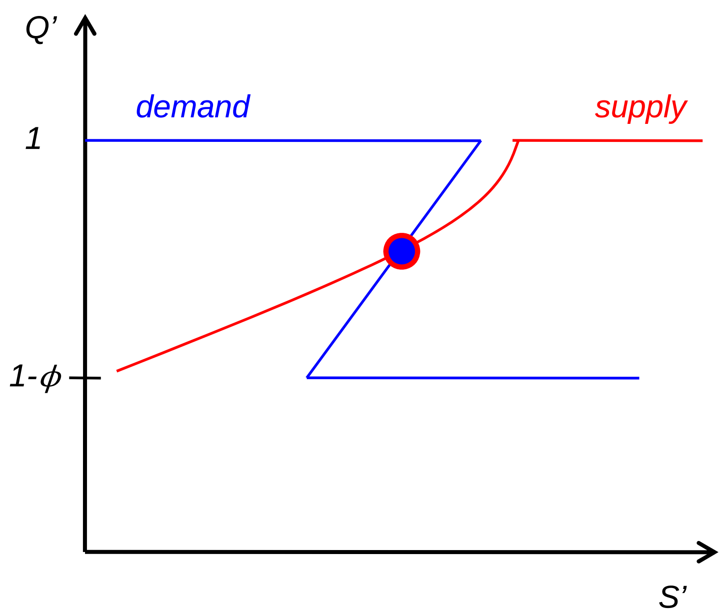


Figure 6. Effect of Injecting Credit through Loans to Lenders and Traders