Interpreting the unconventional U.S. monetary policy of 2007-09*

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Abstract

This paper reviews the unconventional U.S. monetary policy responses to the financial and real crises of 2007-09. It catalogues these policies 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 extensive literature on optimal policy in a liquidity trap. To interpret quantitative policy, it reviews the determination of inflation under different policy regimes, and notes the dangers that current actions raise. To interpret credit policy, it presents a new model of capital market imperfections and their interaction with real investment decisions. In the model, credit supplied to different parts of the financial sector has different effects, and it may improve or worsen the credit constraints in the economy depending on the target.

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1 Introduction

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. At the same time, these have not been good times to be a central banker. The limited tools at the disposal of the Federal Reserve have been hardly 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.

The goal of this paper is to review the Federal Reserve's actions and evaluate them on the light of economic theory. From the start, this is a task doomed to fail, at least to a certain degree. On the one hand, we are still in the midst of the crisis, so that any assessment runs the risk of quickly becoming obsolete. On the other hand, already so much has happened that it would take one (or many) books to account for it all. As a result, I will avoid, as far as I can, making pronouncements on what policies seem right or wrong, even with the benefit of hindsight, and I will also not give a comprehensive account of all the events and policies. The more modest ambition of this paper is to provide an early summary of what has been monetary policy's reaction to the crisis, to interpret this reaction using economic theory, and to raise some of the questions that they bring.

I start in section 2 with brief accounts of the crisis and of the Federal Reserve's behavior, leading to a grouping of monetary policy into three categories. The first category is interest-rate policy, and it concerns the targets for interest rates set by the Federal Reserve. Figure 1 illustrates the recent changes by plotting three key interest rates controlled by the Federal Reserve over the last twenty years. Interest rates are as low as they have been in this period, and the Federal Open Markets Committee (FOMC) has stated its intent to keep them close to zero for the foreseeable future.[1]

Figure 2 illustrates the second set of policies, which I label quantitative policy, and that

[1] The operating procedures for the discount window changed in January of 2003, so there isn't a consistent series for the discount rate for the whole time. For the federal funds rate in 2009, I plot the upper range targeted by the Federal Reserve.

reflect changes in the size of the balance sheet of the Federal Reserve and in the composition of its liabilities. In the figure is the ratio of adjusted reserves held by banks at the Federal Reserve system to annual nominal GDP since 1929. In December of 2008, the ratio was 5.8%, a value only exceeded in the history of the Federal Reserve System during the few months from August of 1939 to December of 1940.[2]

The third set of policies, which I label credit policy, consists of managing the asset side of the Federal Reserve balance sheet. To gauge the radical change in the investments of the Federal Reserve, figure 3 plots the ratio of U.S. Treasury bills held as a fraction of total assets, and the same ratio for total U.S. Treasury securities.[3] From a status quo where the Federal Reserve held almost only U.S. Treasury securities, in the last two years it has switched into many other assets and more recently into securities with longer maturity.

I start my assessment with this last group of policies, because they are the least well 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. In the model, entrepreneurs, lenders, traders and investors all have funds that must be reallocated through the financial system towards investment and production, but frictions may lead to credit shortages in different points of the system. Investments in different assets may improve or worsen the credit constraints, because of the equilibrium interactions between different markets.

Next, I move to quantitative policy, and ask the question: does the increase in the size of reserves and the central bank's balance sheet undermine the current policy regime of controlling inflation? I show that this does not have to be the case, at least according to conventional theory. It may do so, but 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, I turn to interest-rate policy. I briefly survey the literature on optimal monetary policy in a liquidity trap and compare the recommendations from this literature with the

[2] The data are the monthly adjusted reserves computed by the FRB of Saint Louis, and nominal annual GDP from the Bureau of Economic Analysis.

[3] U.S. Treasury bills are 3-month securities, whereas total securities include also longer-duration bonds and notes. The figure includes only the securities held outright, not those held as part of repurchase agreements.

actions of the Federal Reserve. The last section concludes.

2 What has the Federal Reserve been up to?

There are already a few description of the events in the U.S. financial crisis of 2007-09.[4] After a brief and selective summary, the goal of this section is to catalog the policies followed by the Federal Reserve in response to these events.

2.1 The financial and real crisis

In August of 2007, an increase in delinquencies in subprime mortgages led to a sharp fall in the price of AAA-rated mortgage-backed securities together with suspicions about the actual value of their backing. Because many banks held these securities, either directly or through special investment vehicles, there were doubts over the state of bank's balance sheets. Through 2007, there were fears that many banks may 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 of them, notably the markets for commercial paper, private asset-backed securities (ABS), and collateralized debt obligations (CDO), the decline in volume traded was extreme, apparently due to lack of demand.

In the real economy, the U.S. business cycle peaked in December of 2007, according to the NBER. Unemployment has since been steadily rising from an initial 4.9% to a current (in July 2009) value of 9.4%, and measures of output and productivity have also been on the decline. The net acquisition of financial assets by households fell from $1,404 billion in 2007, to $728 billions in 2008, to -$281 billion so far in 2009, although as of the start of 2008, there was still no sharp fall in total bank lending.

Returning to financial events, in March 2008, the investment bank Bear Stearns was 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 a sale of Bear Stearns to JP Morgan Chase, providing government guarantees on some of the assets. Risk spreads remained high and the ABS market was effectively closed for the rest of the

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

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 only finds a rival in the stock market crash of October 1929. It was marked by three distinct events. The first event was the bankruptcy of Lehman Brothers on September 15$^{\text{th}}$, the largest ever company to fail in U.S. history. This investment bank was a counterparty in many financial transactions through several markets, triggering 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$^{\text{th}}$. The bailout not only signalled that financial losses went well beyond investment banks, but it also increased the uncertainty on what would be the government response to future cases. Finally, the third event, on September 20$^{\text{th}}$, was the announcement of the Troubled Asset Relief Program, or TARP (also known as the "Paulson plan"), which was short, vague, and far-reaching on the potential involvement of the government in the economy.

In the six months that followed, the stock market plunged, with the Standard & Poors 500 index falling over 56% between its peak in October 2007 and its trough in March of 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]

The Treasury has throughout these events cooperated with the Federal Reserve, and it has pursued its own policies in response to the crisis. Today, these include a plan to invest up to $250 billion in the capital of banks, offering assistance to homeowners unable to pay their mortgages, and using up to $100 billion of the TARP money in public private investments to buy legacy securities and loans. Since March 2009, some stability has returned to financial markets, with measures of risk spreads shrinking and the stock market partly recovering. Forecasts of unemployment and output show yet no clear signs of improvement.

[5] The situation at the time looked so dire that the head of the International Monetary Fund, Dominique Strauss-Kahn on October 12th stated apocalyptically: "Intensifying solvency concerns about a number of the largest US-based and European financial institutions have pushed the global financial system to the brink of systemic meltdown."

Finally, since inflation measured using year-on-year changes in the Consumer Price Index, has fallen from 4.2% in December 2007 to -1.9% in July of 2009. Inflation forecasts for the coming year, according to the median answer in the Survey of Professional Forecasters, have fallen from 3.6% in the last quarter of 2007 to 0.4% in the second quarter of 2009, while the forecast for average inflation over the next 10 years has slightly risen from 2.4% to 2.5%.

2.2 The Federal Reserve's actions during the crisis

Typically, the Federal Reserve uses a very narrow set of actions in the conduct of monetary policy. It intervenes in the Federal Funds market, where many banks make overnight loans, by open-market operations with a handful of primary dealers, the collateralized purchase and sale 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, this has changed dramatically. Table 1 gives a snapshot of the actions of the Federal Reserve at three points in time: in January 2007 before the start of the crisis (and representative of the decade before), two years later in the midst of the crisis in January 2008, and more recently in July of 2009. The Federal Reserve's policies fit into three broad categories.[6]

The first group is *interest-rate policy*. Starting from a target for the Federal Funds rate of 5.25% for the first half of 2007, the Federal Reserve has gradually reduced it to effectively zero by December of 2008.[7] In its policy announcements, the Federal Reserve has made clear that it expects to keep the rate at zero for a sustained period of time.[8] Starting in October 2008, the Federal Reserve has also been paying interest on both required and excess

[6] For alternative descriptions of the policy responses to the crisis, see Bernanke (2009), and Cecchetti (2009) for the United States, and Blanchard (2009) for the international side. An up-to-date exposition is provided by the Federal Reserve at http://www.federalreserve.gov/monetarypolicy/bst.htm

[7] To be more precise, since December 2008 the Federal Reserve started announcing upper and lower limits for this rate of 0.25% and 0%, respectively.

[8] The December 2008 press release of the Federal Open Markets Commitee (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." This commitment has been re-stated in every meeting since then.

reserves held by commercial banks, and since January of 2009, the interest on reserves has been the same as the Federal Funds rate target. This implies that there is no longer a tax on banks in keeping reserves at the central bank beyond the legal requirements. It also means that the Federal Reserve in the future has at its disposal not just the Federal Funds rate, but a new policy instrument, the spread between that rate and the interest on reserves.[9] Finally, the Federal Reserve has purchased other securities with a stated intent of affecting their prices and yields, although there is little evidence that it has been successful at doing so.[10]

The second group I label *quantitative policy*, and it concerns the size of the Federal Reserve's balance sheet and the composition of its liabilities. Historically, the bulk of the liabilities of the Federal Reserve have consisted of currency in circulation, with a tiny amount of reserves by banks (required by law) and deposits from the Treasury and foreign central banks. With the crisis, the first change is that the Federal Reserve's balance sheet more than doubled. Reserves have accounted for much this increase and they are now mostly voluntary, since the penalty in holding reserves instead of lending in the federal funds market has effectively disappeared once the rates on both became the same. The final significant change in quantitative policy is that the main individual creditor of the Federal Reserve is now the U.S. Treasury. As a means to provide the Federal Reserve with quick access to Treasury securities, the Treasury has greatly expanded the amount in its account, so it now holds more than one tenth of the Federal Reserve's total liabilities.

The third group of policies is *credit policy*. This consist of managing the composition of the asset side of the Federal Reserve's balance sheet. At the start, and similar to how it had always been since its founding, the assets of the Federal Reserve were mostly U.S. Treasury securities, with a little over one third in Treasury bills, and the remaining two

[9] The Federal Reserve also controls the interest rate that it charges banks that borrow from it directly at the discount window. However, even in spite of the liquidity problems that many banks faced in the last two years, very few used this option, so the interest charged through the discount window remains a policy tool that seems to have little influence.

[10] For instance, in April of 2009, vice-chairman Donald Kohn wrote "...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." while chairman Bernanke stated that "The principal goal of these programs is to lower the cost and improve the availability of credit for households and businesses."

thirds in notes and bonds. It also had a few foreign reserves, other assets (e.g., gold) and almost no direct loans. At the height of the crisis, in January of 2009, this picture had changed dramatically, with several new asset-purchasing programs announced.[11] Going down over the items on the balance sheet, first the Federal Reserve significantly shifted the maturity of its Treasury securities from short to long-term assets. Second, the Federal Reserve for the first time made direct loans to entities other than banks, to primary dealers through the 28-day TSLF and the overnight PDCF, and to investors posting as collateral AAA-rated asset-backed securities on student loans, auto loans, credit card loans, and small business administration loans through TALF.[12] Third, the Federal Reserve entered a swap agreement with foreign central banks to temporarily provide them with dollars against foreign currency, increasing the amount of foreign reserves on its balance sheet by a factor of almost 30. Fourth, through the TAF, the Federal Reserve started lending to banks for terms of 28 and 84 days against collateral at terms determined in an auction. These provided a means to lend to banks that kept the recipients anonymity in order to prevent these loans from being seen by the market as a signal of trouble by the debtor bank. In January of 2009 these credits over banks accounted for more than one quarter of the Federal Reserve's assets. Fifth, the Federal Reserve bought 90-day commercial paper through the CPFF, therefore financing many companies directly without going through banks. Sixth, it created three limited liability companies, Maiden Lane LLC, to acquire and manage the assets associated with the bail-outs of AIG and Bear Stearns.

By today, some of these programs have reduced significantly, in particular the holdings of commercial paper and foreign reserves, as can be seen on panel C of table 1. Others though are growing further. In particular, in March 2009, the Federal Reserve announced it would further boost this trend, by purchasing up to $300 billion of long-term Treasury bonds, and $1,450 billion of agency debt and mortgage-backed securities (from Fannie Mae

[11] The initials of different programs are: TAF for the Term Auction Facility, TSLF for the Term Securities Lending Facility, PDCF for the Primary Dealer Credit Facility, CPFF for Commercial Paper Funding Facility, TALF for Term Asset-Backed Securities Loan Facility, AMLF for Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility, and MMIFF for Money Market Investor Funding Facility.

[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, while the funds under the AMLF are included in the "Direct Loans" section of the balance sheet, but have currently a balance of zero.

and Freddie Mac), and it expects to reach these goals by the end of the year. A large share of the plan is already reflected in its August balance sheet.[13]

3 A credit-frictions model of capital markets

The crisis of 2007-09 has involved credit disruptions involving multiple agents in many markets, it has involved large swings in asset-backed securities, and it has propagated form financial markets to the real economy. Unfortunately, there is no off-the-shelf model that contains these ingredients. Before moving to interpreting the Federal Reserve's policies, I must therefore take a detour to introduce a new model that captures these elements.

Financial markets perform many roles, including the management of risk and the transformation of maturity. In the model, I abstract from these better understood roles to focus on a less studied role of financial markets: the re-allocation of funds towards productive uses. I take as given a starting distribution of funds across agents, and 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 (Tirole and Holmstrom (2009)) with the theory of leverage based on collateral constraints (Kiyotaki and Moore (1997), Matsuyama (2007)).

3.1 The set up of the model

There are three periods, no aggregate uncertainty, and four types of agents. The first agent is a representative household, who cares for consumption in the last period (C''), and dislikes working every period (H, H', and H''). His utility function takes the simple functional form:

$$\ln(C'') - (H + H' + H''). \tag{1}$$

[13] These changes were announced at the FOMC meeting of March 2009, but they had been under discussion for a few months before.

There is a wage W paid per unit of labor supplied, while the price of consumption is P. Consumption is a Dixit-Stiglitz aggregator of a continuum of varieties in the unit interval:

$$C'' = \left(\int_0^N Y_i''^{1/m} di \right)^m , \tag{2}$$

where the elasticity of substitution across varieties is $m/(m-1)$, and $N \in [0,1]$ are the varieties that are produced in positive amount. I assume that $m \in [1,2]$, so that markups in this economy will be between 0 and 100 percent. The associated static cost-of-living price index is

$$P'' = \left(\int_0^N P_i''^{1/(1-m)} di \right)^{1-m} . \tag{3}$$

The household has many *investors* behaving competitively, who use total initial funds M. These funds can be interpreted as claims on output in the final period, with the property that they are used to make payments in the first and second period. I refer to them as *capital*, and they can be saved at a zero net interest rate, although generalizing the model to a positive interest rate does not change any of the results.

The second type of agents are *entrepreneurs*. There is a continuum of them in the unit interval associated with each variety of the good. In the first period, they must hire F units of labor to set up operations, so they incur WF fixed installation costs. Further labor is then hired in the second and third periods, to produce monopolistically each variety of the good using the production function:

$$Y_i'' = A_i' \min \left\{ \frac{L_i'}{v}, \frac{L_i''}{1-v} \right\} . \tag{4}$$

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

This production structure captures the maturing process of investments, with expenses in every period to finally get a payoff in the last period, together with the risk that set-up

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.

The third type of agents are *lenders*. Their distinguishing feature is that they are the only ones with 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, instead, can prevent the entrepreneur from absconding with no more than a share δ of the sales revenues. Entrepreneurs can therefore pledge $1-\delta$ of the revenues to lenders and 0 to all others.[14] I assume that $(1-\delta)m > 1$, which will ensure that pledgeable revenues are enough to ensure positive pledgeable profits to lenders. A lender will provide the needed funds to start the project, $WF-K$, as well as a line of credit in the second period to pay for the wages WL'.

To fund these investments, lenders have capital D in the first period, and possibly a new infusion D' in the second period. If they require further financing, they can issue and sell asset-backed securities, guaranteed by the loans they make, in total dollar amount S for price Q in the first period, and S' and Q' in the second period. These securities pay \$1 in the last period, as long as the project is in operation. In the data, lenders include all the providers of financing to the non-financial sectors, including commercial banks, primary issuers of commercial debt, some brokers, etc.

The fourth and final group of agents are *traders*. While they cannot monitor loans, together with lenders, they have the unique ability to understand and trade the 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 ones that can verify that there is proper backing for a recently issued security. Traders also observe the realization of productivity in the second period, while investors do not. They therefore perform the role of intermediating the access of investors to the securities. In the United States, traders include investment banks, hedge funds, special investment vehicles set up by commercial

[14] This limited pledgeability constraint has a long tradition in the modelling of capital market imperfections: see Matsuyama (2007) and Tirole and Holmstrom (2009) for recent reviews. Note that one can re-interpret the F set-up costs as being the cost for lenders to set up the monitoring technology that only they have access to allowing to seize δ of the revenues.

banks, and many others.

Traders have capital E in the first period, and an extra E' available in the second period. They can obtain extra funds from investors, but I assume there is another friction preventing investors from effectively owning the traders and acquiring access to their information technology. I again use a pledgeability constraint, assuming that investors can only seize a share $1-\mu$ of the assets of a trader, so this is the maximum amount of liabilities the trader can have. Therefore, in the first period, the total assets of the trader 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 $E+(Q'/Q-1)S$ reflecting the capital gain (or loss) made on these investments. Because the trader can get new loans against this marked-to-market equity position, they can invest a further $[(1-\mu)/\mu](Q'/Q-1)S$ in the second period. This ability to use capital gains to boost leverage is also emphasized in Krishnamurthy (forthcoming) and Shleifer and Vishny (2009).[15]

Having presented the agents, I now describe the markets in which they interact at each date. In the first period, entrepreneurs need financing to set up their firms. Because of limited pledgeability, only lenders are willing to provide them with funds. 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 funds, they can issue securities, that only traders will choose to buy since only they can ensure that the securities are legitimate. Investors deposit funds in traders. I assume that $K+D+E<WF$, so that everyone's funds, including investors, is required to set up all the projects.

In the second period, entrepreneurs require more funding 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. At his time though, investors can also buy the pre-existing securities, because lenders and traders have signalled they are backed by loans by trading them in the first period. However, investors cannot distinguish securities backed by assets with $A_i'=a$ from those with $A_i'=0$. Therefore, as long as $Q'>1-\phi$, they will stay out of buying

[15] 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 leads to zero revenue. Therefore, investors are not willing to lend to them.

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, the entrepreneur obtains the revenue from sales, pays the last-period workers and pays back the loan to lenders. They use part of the fund to repay the holders of securities backed by the loans, while traders repay their loans to investors. In the end, all return their funds to the representative household who buys the consumption good. 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 $M + D + D' + E + E' > K + vWL'$ so that there is enough liquidity to sustain the social optimum, where all projects get funded and marginal costs are W/a. The problem I focus here is on the allocation of this liquidity, in the presence of the frictions captured by the three positive parameters, δ, ϕ, and μ.

3.2 The solution of the model

I normalize the price of consumption P to 1, so the consumption bundle is the numeraire. Consumer optimality then requires that:

$$C = W, \tag{5}$$

$$Y_i'' = C{P_i''}^{m/(1-m)}. \tag{6}$$

The lender and entrepreneur jointly decide the optimal scale of production for the productive firms in periods two and three to maximize joint returns:

$$\max_{P_i'', Y_i'', L_i', L_i''} \left\{ P_i'' Y_i'' - WL_i'/Q' - WL_i'' \right\} \tag{7}$$

subject to the production function and the demand for the good in equations (4) and (6). The optimality condition is:

$$P_i'' = m\left(1 - v + v/Q'\right) W/a, \tag{8}$$

together with $L' = v(L' + L'')$. In the symmetric equilibrium, with $N = (1-\phi)I$ firms producing, $C = [(1-\phi)I]^m Y$ and $P_i'' = [(1-\phi)I]^{m-1}$. Combining all of these equations provides the solution for wages, total employment in the second and third periods, and the pledgeable amount of profits:

$$\begin{aligned} L' + L'' &= \frac{1}{m\,(1 - v + v/Q')\,(1-\phi)I} && (9) \\ W &= \frac{a\,[(1-\phi)I]^{m-1}}{m\,(1 - v + v/Q')} && (10) \\ \pi_i(Q', I) &\equiv (1-\delta)P_i''Y_i'' - WL_i'/Q' - L_i'' \\ &= \frac{[(1-\delta)m - 1]\,a}{m^2\,(1 - v + v/Q')\,[(1-\phi)I]^{2-m}} && (11) \end{aligned}$$

Turning to the securities markets, there are two restrictions on prices that come from no-arbitrage. First, note that a security bought in the first period for price Q will, with probability $1-\phi$, be worth Q' next period and with probability ϕ be worth 0. Because lenders can sell a security for Q in the first period and buy it back for Q' in the second period, it must be that $Q \leq (1-\phi)Q'$, otherwise they would make infinite expected profits.[16] Second and similarly, because lenders can hold cash between the second and third periods 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 $Q < (1-\phi)Q'$, traders strictly prefer to buy securities rather than hold cash so their total demand is E/μ. If $Q = (1-\phi)Q'$, they are indifferent between cash or securities, so they will be willing to buy any amount of securities below E/μ. Turning to the supply of securities, if $Q < (1-\phi)Q'$, it equals the total investment minus the capital of the entrepreneur and the lender: $WFI - K - D$. If $Q = (1-\phi)Q'$, the lender is indifferent between issuing this amount of securities or any higher amount. Equating demand and supply for $Q < (1-\phi)Q'$, and replacing for equilibrium wages from equation (10), gives the first-period securities-market equilibrium

[16] The fact that capital gains on holding a portfolio of securities are always non-negative is a consequence of the lack of aggregate uncertainty. It is straightforward to extend the model to have uncertainty; since all agents are risk-neutral this would change almost nothing in the analysis after replacing expected for actual values.

condition (SM):

$$I^m = \left(K + D + \frac{E}{\mu}\right)\left[\frac{m}{a(1-\phi)^{m-1}F}\right]\left(1 - v + \frac{v}{Q'}\right). \tag{12}$$

In (I, Q) space this defines a vertical line for Q between 0 and $(1-\phi)Q'$.

The expected profits of lenders in the first period are $IQ(1-\phi)\pi(Q', I) - WFI + K$. There is free entry into this sector, so lenders will enter as long as there are available projects, and profits are. If Q is above a certain level Q^*, then $I = 1$, and lenders earn positive rents in exchange for their monitoring services.[17] If $Q \leq Q^*$, then lenders' profits are driven to zero so $IQ(1-\phi)\pi(Q', I) - FWI + K = 0$. Solving this equation for I, and replacing for pledgeable profits from equation (11) gives:

$$a(1-\phi)^{m-1}I^m\left(F - \frac{Q\left[(1-\delta)m - 1\right]}{mI}\right) = Km\left(1 - v + v/Q'\right) \tag{13}$$

This is the zero-profits equilibrium condition for when $Q \leq Q^*$ and investment is below one (ZP). It defines investment implicitly as an increasing function of Q. Intuitively, as the price of securities increases, financing is cheaper, 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 $1 - \phi < Q' < 1$, the demand comes solely from traders and equals:

$$S' = \frac{E'}{\mu} + \left(\frac{1-\mu}{\mu}\right)\left(\frac{(1-\phi)Q'}{Q} - 1\right)\left(\frac{E}{\mu}\right). \tag{14}$$

The first term is the demand from the new capital and the second term is the extra demand form leveraging capital gains. If $Q' = 1$, the trader is indifferent between zero and the amount in equation (14). As Q' falls, the expected capital gain for traders is smaller and so they have fewer funds to demand securities. If Q' falls all the way to $1 - \phi$, then investors start buying securities directly satisfying the supply at that price.

[17] Q^* is defined as:

$$Q^* = \frac{WF - K}{(1-\phi)\pi(Q', 1)}.$$

The supply of securities comes from lenders who need funds to cover their outstanding credit lines, so it equals $WL'(1-\phi)I - D'$ if $Q' < 1$. Replacing for the equilibrium labor and wage from equations (9)-(10) gives the supply function for securities in the second period:

$$S' = \frac{va(1-\phi)^{m-1}I^{m-1}}{m^2\left(1-v+v/Q'\right)^2} - D'. \tag{15}$$

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, so higher credit lines, and more securities issued. When $Q' = 1$, the lenders become indifferent between supplying this and any higher amount.

Conditions (12)-(15), provide four conditions to determine the equilibrium price of securities in the first and second period, and the amount of investment in the first period and scale of operations and funding in the second period. Together they define the equilibrium in this economy. There are three possible equilibria that I describe next.

3.3 The three possible equilibria

The first case is the *efficient economy* where, in spite of the financial frictions, still all projects are funded $I = 1$ and financing does not add to the marginal cost of firms: $Q' = 1$. One can show that this 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' revenues, so their profits are high enough and they wish to finance all the projects. If μ is low, the friction impeding the flow of funds from investors to traders is not too severe so their funds can satiate the markets for securities. Finally, if ϕ is low, the expected profits of lenders at date 1 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, of a *catastrophic economy*, where the price of securities in the second period has fallen to $1-\phi$. Investors start buying securities directly, but because they cannot distinguish profitable from unprofitable assets, for each dollar they spend on a a worthwhile security, $\phi/(1-\phi)$ dollars buy a worthless security, squandering funds. This low price of securities implies that the marginal cost of production $(1-v+v/Q')$

is high so that each firm will be operated at a low inefficient scale. And as Q is even lower, below $(1-\phi)^2$, the cost of financing to set up projects in the first period is very high and few firms are set up in the first place.

In between these extremes is the *constrained economy*. Figure 5 plots the equilibrium graphically. In the top panel, the equilibrium price of securities and 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 (12), while the upward-sloping curve is the ZP condition in equation (13). The bottom panel has 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 line depicts the demand function in equation (14), while the curve is the supply function in equation (15). In this economy, there is an extensive margin inefficiency as $I < 1$. Traders do not have enough assets, either because of low capital or tight leverage constraints from investors, so the price of securities Q is below Q^*, making the up-front cost of investing too high relative to the future revenues. There is also an intensive-margin inefficiency since $Q' < 1$ so the marginal costs of production exceed W/a. Operating firms will hire too little labor and produce too little output, because there isn't enough second-period capital in the hands of traders to satisfy the residual need for funds by lenders.

Intuitively, for the economy to be operate efficiently, investor's funds must reach entrepreneurs via traders and lenders and through the securities market. In the efficient economy, this happens as entrepreneurs are stated with all the funds they need to set up and operate projects. In the constrained economy, leverage constraints on traders are too tight, so 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 at great waste since they are unable to pick securities. There is severe mis-pricing and misallocation of funds, as worthless and worthwhile investments face the same marginal cost of funds in an inefficient pooling equilibrium.

4 Interpreting the Federal Reserve's actions: credit policy

In terms of the model just described, the financial events and crisis described in section 2.1 can be interpreted as a combination of two effects. First, the downgrading of many securities, following revisions downward of the underlying 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 solvability of many financial institutions, can be interpreted as an increase in μ. The economy in 2007-09 was in a constrained equilibrium like the one depicted in figure 5, or perhaps even on the way to the catastrophic equilibrium described in the previous section.

The Federal Reserve would like to intervene to correct this serious misallocation of funds. What it can achieve depends on we assume about its power and skills. I consider several cases, from the more modest to the more optimistic.

4.1 The Federal Reserve as just another investor

If is a useful benchmark to start with the case where the Federal Reserve, like the investors in the model, does not have the ability to monitor loans, does not have the know-how to pick securities, and does not have the power to be able to seize more than $1-\mu$ of traders' assets. In this case, any injection of credit by the Federal Reserve 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 the lack of funds, but their mis-allocation. Worse, if the Federal Reserve misguidedly tries to pick securities, invest in traders, or make loans directly to entrepreneurs, its sub-optimal behavior will lead to possibly heavy losses, as money is absconded and investments turn in losses.

4.2 The Federal Reserve as a senior secure investor

The Federal Reserve has the ability to make loans to financial institutions that will surely be fully paid, either by imposing that they are senior to other creditors, or by using its regulatory power.

In the model a transfer of funds X 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.[18] 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 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 expected profits of banks, shifting the zero-profit condition to the left and lowering investment, and so on. As a result of the Federal Reserve's actions, more firms are in operation, but each at a smaller inefficient scale.

In comparison, consider what happens if the loans X are to traders instead, 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 funds to lenders. However, in the second-period market, the increase in 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 to demand securities in period 2, so the demand curve will be to the right of the one in the lenders case (in the figure it is drawn as unchanged form the initial case). Therefore, the price of second-period securities falls less than it did with the Federal Reserve's loan to lenders. This intervention does not have the same intensive-margin inefficiency that the loan to lenders did.

Alternatively, consider providing loans to traders or lenders in the second period. Briefly staring at the two equilibrium conditions, equations (14) and (15), and seeing that E'/μ and D' enter symmetrically, it follows that loans to traders or lenders would have an equivalent effect. They would raise Q' and improve intensive-margin inefficiency. At the same time, they lower investment in the first period (see equation (12) and so worsen the extensive margin.[19] Note that the crucial difference between first and second period in the model is

[18] This assumes that the Federal Reserve is not trying to make profits from the loan, so the net interest rate it charges is zero.

[19] Leave the constrained equilibrium and reaching the efficient one, would require large loans X in either

whether the securities are coming due next period or not. The indifference between injecting funds in traders and lenders applies only to the securities that are about to mature; for all other securities, loans to traders are more effective because they affect traders' equity and leverage in future periods.

The theory therefore suggests that providing funds to traders of new securities is more effective than doing so to lenders. The intuition is that, through capital gains, traders can use increases in equity to raise their leverage and draw more of the plentiful funds in the hands of investors to where they are scarce and needed in the securities markets. For the Federal Reserve, it is more natural to extend loans to commercial banks, as it involves little departure from its common procedures. The creation and popularity of the 90-day loans under TAF, instead of the overnight loans in the Federal Funds market, are an example of directing funds to lenders. At the same time, programs such as the TSLF, PDCF, and TALF are closer to the injection of funds into traders that the model recommends.

4.3 The Federal Reserve as a buyer of securities

Next, consider the stricter case where the Federal Reserve 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 Federal Reserve can use its funds X to buy securities directly, shifting the demand curve on the right 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 just discussed.

The Federal Reserve followed this path for part of 2008 through the CPFF program that bought commercial paper, although it has moved away from it in 2009. 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.

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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.

4.4 The Federal Reserve 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 the uncomfortable actions in support of the rescue of Bear Stearns and AIG make it close to being a de facto investor.[20]

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, the difference is that with 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.

However, this is only a good option in the model if the Federal Reserve can prevent its partners from absconding with a share μ of the assets.[21] Moreover, in real life, it requires that the government behaves like a profit-maximizing shareholder in the firms. Both conditions are probably unlikely, or at least come with some risk.[22]

5 Interpreting the Federal Reserve's actions: quantitative policy

The large increase in the amount of 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", 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 to be skeptical of the tight link between money and inflation that a strict monetarist stance would suggest. Empirically, the attempts at money

[20] The discomfort with these actions is clear in the 2009/04/09 speech by Ben Bernanke, regarding Maiden Lane LLC: "[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."

[21] In reality, this absconding is not literal. It may involve picking dishonest partners, as well as having them put less than efficient effort, or divert company investments towards private gains rather than the firms' profits.

[22] I do not consider the case where the Federal Reserve can become a lender, being able to monitor the behavior of borrowers. This not only seems unrealistic, but it also has absurd predictions: if the Federal Reserve could do loans as effectively as anyone else, then why have a financial system at all?

targeting in the United States and the United Kingdom in the early 1980s were a failure, and even though Japan in the 1990s increased reserves in a similar scale to the United States, deflation persisted. Theoretically, conventional models of inflation predict that reserves are irrelevant for the setting of interest rates or the control of inflation.[23] This section discusses these theoretical arguments and examines to what extent the crisis may have modified them.

5.1 A simple model of price-level determination

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

$$
\begin{aligned}
(1+i_t)P_t/P_{t+1} &= C_{t+1}/\beta C_t && (16)\\
M_t/P_t &= L(i_t - i_t^m, C_t) && (17)\\
P_t G_t + i_{t-1}B_{t-1} &= P_t T_t + V_t + B_t - B_{t-1} && (18)\\
B_t &= B_t^P + B_t^F && (19)\\
V_t + i_{t-1}^m M_{t-1} + B_t^F - B_{t-1}^F + K_t - K_{t-1} &= M_t - M_{t-1} + i_{t-1}B_{t-1}^F + q_{t-1}K_{t-1} && (20)\\
\ln(1+i_t) &= \chi \Delta \ln(P_t) + x_t && (21)
\end{aligned}
$$

The first equation is the Euler equation for consumption equating 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. The second equation 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, then holding fixed the other determinants of the demand for reserves, the private sector is indifferent between holding any amount of reserves above some satiation level. This was the case considered in the model of the previous section.

The following two equations refer to the behavior of the Treasury. Equation (18) is the budget constraint. On the left-hand side are resources spent on government spending

[23] See Woodford (2008) among many others.

(G_t) plus the payment of interest on outstanding bonds (B_t). On the right-hand side are the revenues, from taxes (T_t), transfers from the Federal Reserve (V_t), and issuances of new debt. The following equation is the market clearing condition for government debt, which may be held by the Federal Reserve (B_t^F) or by private agents (B_t^P).

The final two equations apply to the central bank. It spends funds in transfers to the Treasury, pays interest on reserves, and buys either government securities or private assets (K_t). This spending is 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 $\chi > 1$.[24]

To focus on the price level, I take consumption as exogenous, and to focus on monetary policy, government spending is also exogenous. The Federal Reserve's policy is captured by its choices of interest rates $\{x_t, i_t, i_t^m\}$, quantitative policy on the amount of reserves and transfers to the Treasury $\{M_t, V_t\}$, and credit policy on what assets to hold $\{B_t^F, K_t\}$. The Treasury's policy is captured by the choices of taxation and debt issuance $\{T_t, B_t\}$. 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.[25] A policy regime is a choice of which of these policy variables are exogenously chosen, and which must endogenously accommodate.

5.2 The pre-crisis policy regime

For most of the last twenty years, the press releases and commentary following meetings of the FOMC have focussed on the current choice of innovations to the short-term interest rate, x_t, as well as its likely path in the future. Combining equations (16) and (21) and solving forward, the unique bounded solution for the price level is

$$\Delta \ln(P_t) = \frac{\ln(\beta)}{1-\chi} + \sum_{j=0}^{\infty} \chi^{-j-1} \left[\Delta \ln(C_{t+1+j}) - x_{t+j}\right] \tag{22}$$

[24] Adding a real activity to make this rule close to the Taylor rule would not change anything in the analysis.

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

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 (16)-(21), understanding and forecasting inflation involves focusing solely on the target rates announced by the FOMC. Independently of how the other variables are determined, it is the Federal Funds rate that determines inflation.

Turning to the other variables, the policy rule in (21) determines endogenously the observed short-term interest rate i_t. The other exogenous interest rate is i_t^m, which before October 2008, was set at zero. The money demand equation (17) 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 simply accommodated the fluctuations in the demand for reserves.

As for credit policy, before 2007, the Federal Reserve chose to have almost no private security holdings ($K_t \approx 0$) 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 (20), reduces to:

$$V_t \approx i_{t-1} M_{t-1}, \tag{23}$$

approximately in steady state. With these policy choices, the Federal Reserve obtained a net income of 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 (23) with the Treasury's budget constraint in (18), the market clearing condition for bonds in (19), and the transversality conditions gives:

$$B_t^P = P_t(G_t - T_t) + (1 + i_{t-1})B_{t-1}^P - \Delta M_t, \tag{24}$$

$$\sum_{j=0}^{\infty} \left[\frac{P_{t+j}\left(T_{t+j} - G_{t+j}\right) + \Delta M_{t+j}}{\prod_{k=0}^{j}\left(1 + i_{t-1+k}\right)} \right] = B_{t-1}^P. \tag{25}$$

The Treasury can chose a path for deficits subject to the intertemporal solvency constraint in (25), and the total amount of outstanding U.S. debt evolves endogenously to satisfy equation (24).

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 size of operating surpluses $P_{t+j}\left(T_{t+j} - G_{t+j}\right)$, this dependence has been close to irrelevant.

Until recently, both the independence of the central bank to set interest rates and control inflation as well as the irrelevance of reserves, were seen as hallmarks of good monetary policy.[26] Some have even argued that this policy regime partly explains the decline in macroeconomic volatility in the two decades before the crisis.[27]

5.3 Is the pre-2007 status quo sustainable?

The crisis has brought significant changes in monetary policy. However, by themselves these do not imply that the determination of the price level must be different than what was just described. The FOMC can still choose independently 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 the other variables in the system. First, by now being able to pay interest on reserves, the Federal Reserve can choose exogenously either $i_t - i_t^m$, or the quantity of reserves M_t. Unlike before, when the interest on reserves was fixed at zero, the Federal Reserve 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 Federal Reserve 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 Federal Reserve 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 pre-2007 and that Friedman (1969) and 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 private holdings of

[26] See Woodford (2003) and Mishkin (2009).
[27] Bernanke (2004/02/20).

securities, receiving in return government bonds until again these are approximately equal to the amount of reserves. The only substantial change is that now, with the removal of the tax on reserves, the 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 I just described. The Federal Reserve has been firm in its commitment to set interest rates to control inflation and to maintain its independence.[28] Moreover, there is no indication of reversing the decision to pay interest on reserves. And finally, the Federal Reserve has indicated that it would like to lower its holdings of private securities to as close to zero as possible as soon as it can.[29]

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 possible, it would lower reserves and the size of its balance sheet.[30] 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 and eliminated the tax on reserves, the old money multiplier that linked reserves to the price level broke down.

[28] From the joint statement of the Federal Reserve and the Treasury on 2009/03/23: "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 "

[29] As vice-chairman Kohn put it in a speech in 2009/05/23: "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."

[30] Bernanke (2009/04/03) stated: "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."

5.4 The capital and fiscal risk to the status quo

The main risk to the previous scenario comes from the Federal Reserve's flow of funds in equation (18). Now that interest is paid on reserves, and that reserves have more than doubled, the term $i^m_{t-1}M_{t-1}$ can become significant as soon as i^m_{t-1} increases from zero in tandem with the Federal Funds rate. Moreover, with the Federal Reserve holding a significant amount of private securities, it is possible that the return on these securities may be negative, lowering revenues by the amount $q_{t-1}K_{t-1}$.[31] How can the Federal Reserve make up for this budget shortfall?

The budget constraint in equation (18) gives the answer. One way is to sell government bonds, effectively handing some of them over as interest payments to the holders of the reserves. This cannot go on forever though, as the Federal Reserve will eventually run out of bonds, even if it can offset income losses for quite a while. Going back to panel C of table 1, if the interest rate gets as high as 5%, the Federal Reserve can pay its interest on reserves for more about 20 years exclusively by selling government bonds and agency debt.[32]

Another way is to print money or raise reserves. If the economy is already satiated with reserves, then 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 of creating excess and possibly idle reserves.[33]

There is one caveat to this option. If there are significant negative returns on its portfolio, the accounting capital of the Federal Reserve may become negative. As the Federal Reserve's assets fall by selling bonds or its liabilities rise by issuing reserves, liabilities may come to exceed assets. If the Federal Reserve was a common company, this would mean that it was bankrupt. However, the Federal Reserve is not a common company because

[31] The Federal Reserve has repeatedly stated that it believes the risk of losses is negligible (Bernanke, 2009/01/13), because in most of its programs, it is taking AAA-rated securities as collateral and imposing significant haircuts. There is reason to be a little skeptical. First, if the investment were riskless, we 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.

[32] If the Treasury requests that its acount is closed and the bonds it has deposited returned, then the bonds would last for 15 years.

[33] Note that this option relies on the existence of a finite satiation level in the demand for reserves. Otherwise, printing money would compromise the Federal Reserve's target for inflation.

it can issue liabilities (reserves) that are legal tender. There cannot be a run of creditors on the Federal Reserve, because it can simply pay them with the reserves it issues. The accounting capital of the Federal Reserve is a vacuous concept. The source of concern is that, as Berriel and Bhattarai (2009) document, most central banks including the Federal Reserve, do seem to worry about their capital. As they show, if the central bank worries about maintaining a target level of capital in its balance sheet, this will affect the path of interest rates away from what would be desirable.

The third option is the more troublesome. To pay for its budget shortfall, the Federal Reserve may 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.[34] Once transfers from the taxpayer to the Federal Reserve must be regularly approved by Congress, political pressures on the setting of interest rates are inevitable. There is a real danger that this will lead to permanent increases in inflation in exchange for only short-lived boosts to output, as the U.S. economy falls in the time-inconsistency trap described in Kydland and Prescott (1977).

In the extreme, this loss of independence may even trigger a change in policy regime. In particular, take the scenario where Congress limits the fiscal plans of the executive branch by imposing a target for government debt as a ratio of GDP (or consumption): B_t/C_t. The Treasury could accommodate this target by cutting deficits. But, as an alternative, it may choose a value for nominal deficits exogenously, and this is consistent with an equilibrium, as described in Sims (1994) and Woodford (1995). The equilibrium price level would be:

$$P_t = \frac{B_t/C_t}{\sum_{j=1}^{\infty} \beta^j (T_{t+j} - G_{t+j})/C_{t+j}} \tag{26}$$

and inflation would be solely determined by the fiscal choices. The Federal Reserve would then be forced to accommodate these fiscal policies by effectively giving away control of the nominal interest rates, with x_t determined endogenously to satisfy:

$$x_t = \Delta \ln(P_{t+1}) - \chi \Delta \ln(P_t) + \Delta \ln(C_{t+1}) - \ln(\beta) \tag{27}$$

[34] Indeed, conventional measures of central bank independence, usually use budgetary independence from the legislative bodies as a pre-requesite (see the recent survey in Cukierman (2008)).

This fiscalist determination of inflation requires the Treasury to be dominant over the Federal Reserve in setting policy—the literature has called it the fiscal authorities being active and the central bank passive.[35]

6 Interpreting the Federal Reserve's actions: interest-rate policy

Regarding 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 it 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 that are indifferent between money and bonds to simply substitute one for the other. Conventional monetary policy appears to be powerless.

There is an extensive literature arguing 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 as well as some policy advice to confront them. Rather than being ineffective, choosing the right path for interest rates is particularly important during a liquidity trap.

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, $E_t\left(\Delta P_{t+1}\right)$:

$$r_t = i_t - E_t\left[\Delta \ln(P_{t+1})\right]. \tag{28}$$

Moreover, recall 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

[35] For further exploration of the implications of this fiscal theory of the price level within the crisis crisis, see Sims (2009) and Cochrane (2009).

sum of short-term real interest interest rates between the two periods:

$$E_t \left[\ln(C_{t+s}) - \ln(C_t)\right] = E_t \left(\sum_{j=0}^{s-1} r_{t+j} \right). \tag{29}$$

Intuitively, the higher is the long-term real interest rate, which is equal to the expected path of the 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. If inflation expectations remain stable and low, equation (28) may imply that the nominal interest rate would have to become negative to generate the needed real interest rate. Because this cannot happen, the nominal interest rate hits the zero lower bound, and real interest rates are too high.[36] Equation (29) then implies that these excessively high real interest rates drive down current consumption, worsening the current recession.

However, as Krugman (1998) emphasized, monetary policy is particularly potent in this time if it can steer inflation expectations. The way out of the trap is to raise inflation expectations in whatever way possible so that the short-term real interest rate can fall encouraging consumption. Eggertsson and Woodford (2003) provided a practical alternative by noting that the Federal Reserve can commit to keep nominal interest rates low into the future, even after the shocks leading to the crisis has subsided. This would lower expected future short-term real interest rates, producing the desired fall in the long-term real interest rates that drives real activity up.

There are several other alternatives to raise inflation expectations, bring down real interest rates, and stimulate the economy. Devaluing the exchange rate is one, and another is to purchase government debt with a permanent increase in the money supply that again

[36] 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 give positive profits and an arbitrage opportunity. This is only approximately correct since the expected return on money is not exactly zero, but is slightly negative, as deposit accounts pay fees and cash held in pocket may be stolen. Still, 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. This has to my knowledge, never been tried in history.

persists after the crisis has passed. A more institutional approach that would prevent the problem from appearing in the first place would be to announce a price-level target since this requires that current deflation is offset by expected future higher inflation to get back on the target. A final alternative is to commit to lower long-term nominal interest rates, as this is equivalent to committing to a lower path of short-term interest rates.[37] It is important to note that these are not alternatives to the increase in inflation expectations achieved by committing to low nominal interest rates into the future. Rather, they are different ways to express the same policy in terms of its different consequences.

How do the Federal Reserve's actions compare to these theoretical suggestions? While the Federal Reserve has not announced a commitment to obtain 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 in 2009 have stated the intention to keep the target for the Federal Funds rate at zero for a prolonged period of time. These are some signs that the advice of Krugman, Eggertsson and Woodford is being followed.

At the same time, the other expressions of commitment to this policy are absent. First, announcing a devaluation of the exchange rate 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, as the dollar value of Treasury-issued securities plus agency debt held by the Federal Reserve in August 2009 had only gone up to $847.9 billions relative to $778.9 billions in January of 2007. While the Federal Reserve has announced that it will expand the purchase of government bonds substantially in the coming months, it has also indicated that this might be temporary, as it returns to a balance sheet size similar to that in the past once the crisis subsides. Third, the change in the maturity composition of these securities to longer-term bonds is consistent with perhaps trying to lower long-term interest rates, but there is little evidence that this portfolio shift can have any effect on long-term interest rates beyond what the announcement of lower future short-term interest rates do.

A crucial part of the Federal Reserve's policy is its future actions after the crisis subsides,

[37] 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).

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, and yet this is a crucial component of optimal policy according to the theory just discussed.

7 Conclusion

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

With regards to its interest-rate policy, the Federal Reserve has followed the advice from theory by committing to fight deflation and to keep interest rates at zero for the foreseeable future. It has deviated from the theoretical recommendations by not making a clear commitment to have 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 regards 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 separation between monetary and fiscal policy would have to change. Both of these have been lauded as hallmarks of the successes in monetary policy in the past two decades. However, there is a danger brought by the combination of an expansion in the Federal Reserve's balance sheet, interest payments on reserves, and assets with risky returns. The Federal Reserve might face significant budget shortfalls, and over-reacting to these may lead to surrendering independence to fiscal policy, potentially compromising both of the hallmarks above.

Finally, regarding credit policy, I introduced a new model of the financial market's role in allocating funds subject to credit frictions. I considered the merit of different interventions according to the model and to alternative beliefs on the knowledge and power of the Federal Reserve. The model suggested that injecting funds into firms that trade asset-backed securities through senior loans is an effective way to intervene in the financial

markets. Theoretically, this seemed superior to lending funds to the originators of loans, to buying securities directly, or to 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 we know so little in this area. More likely, looking back in a few years and using either the model in this paper or those that follow, some of the credit policies will be seen as ineffective or even harmful.

In spite of jumping across many different topics, models, and policies, I have ignored many facets of the crisis and of monetary policy.[38] Writing this interpretation of the Federal Reserve's actions came with the privileges of being selective and of having some hindsight. Neither of the two were available to the Federal Reserve and other central banks in the past two years.

[38] Two notable omissions were the consideration of aggregate risk and the changes in risk spreads, and the role of foreign investors and the external deficit. On the first, see Curdia and Woodford (2009), and on the second see Caballero et al. (2008).

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Figure 1. Interest rates controlled by the Federal Reserve, 1989:8-2009:8

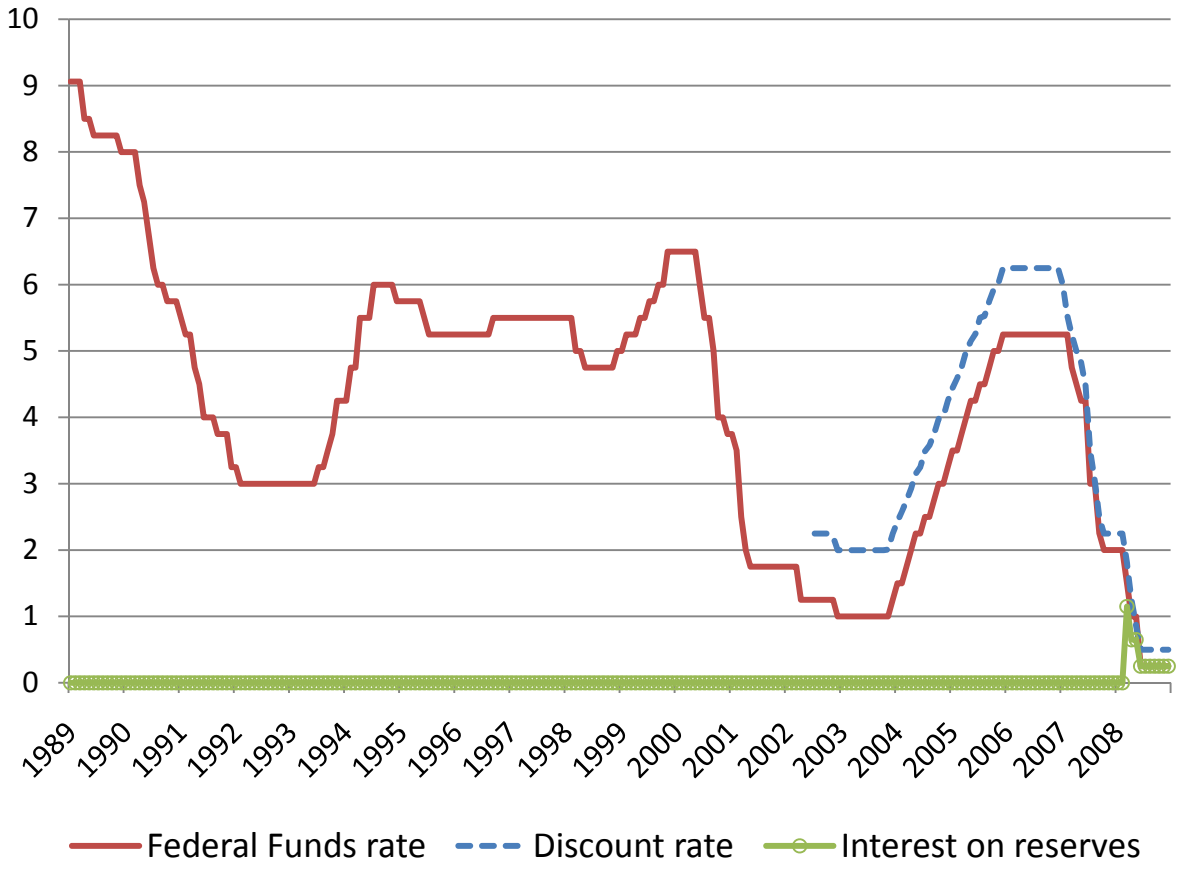


Figure 2. Adjusted reserves divided by annual U.S. GDP, 1929-2009

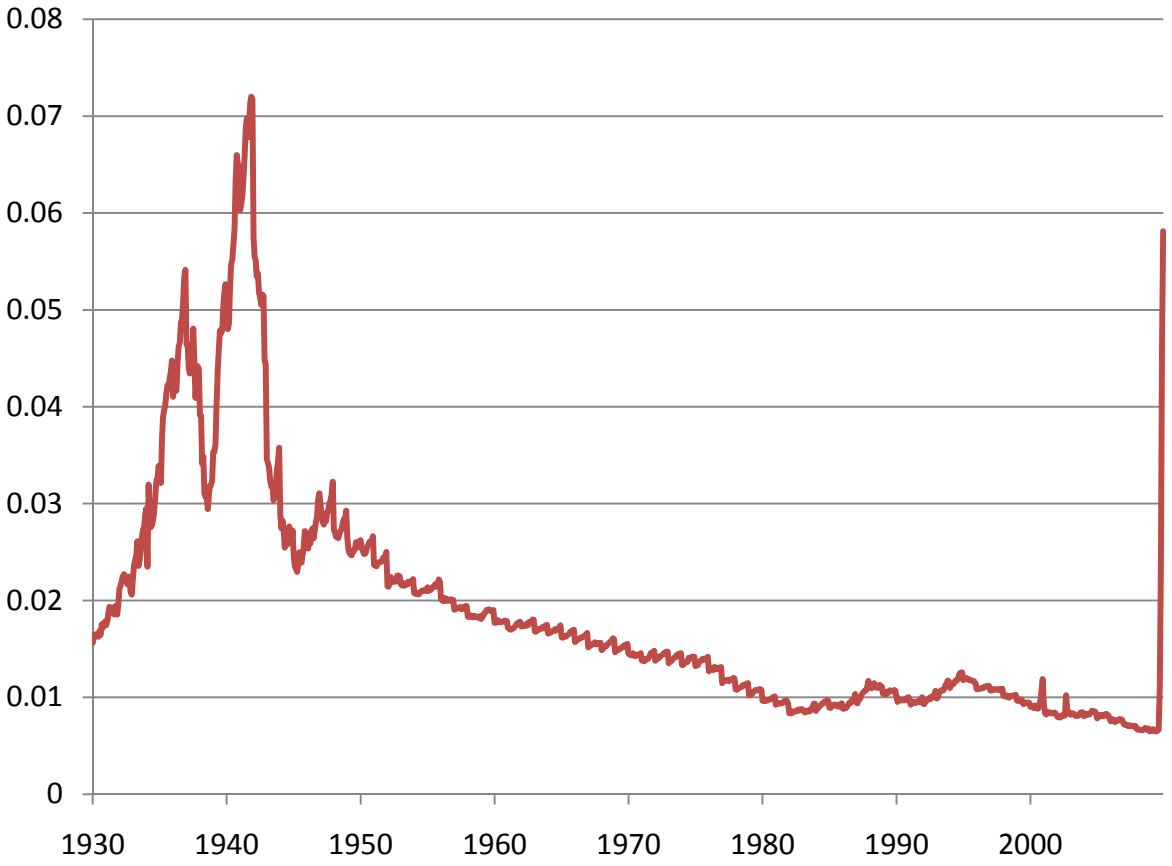


Figure 3. Treasury securities held outright divided by total assets, 1996:6-2009:8

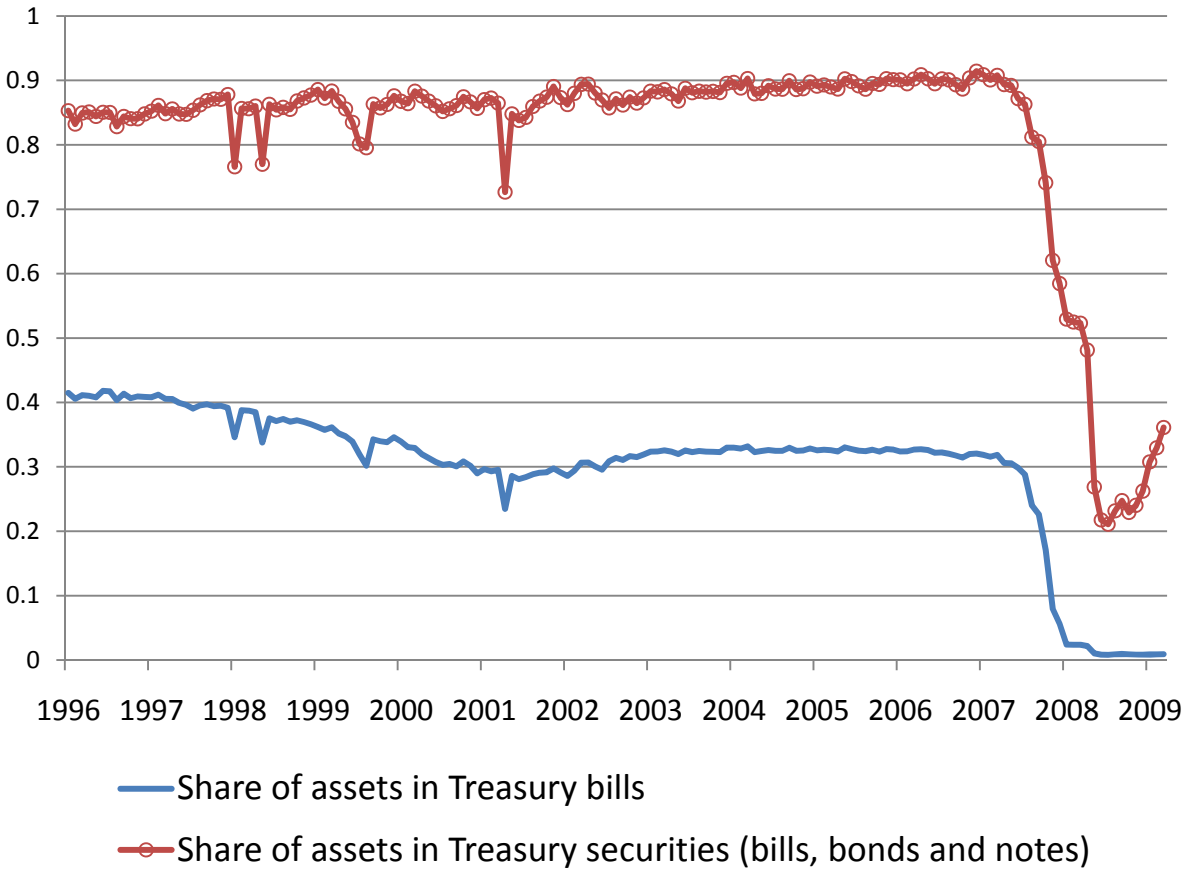


Table 1. Three snapshots at the actions of the Federal Reserve

***Panel A**. January, 4, 2007*

Federal Funds Target Rate: 5.25%

Balance Sheet (in billions of dollars)

Assets		**Liabilities**	
Securities held outright		Federal Reserve notes	781.3
U.S. Treasury bills	277.2	Commercial bank reserves	20.0
U.S. Treasury notes and bonds	501.7	U.S. Treasury deposits	6.2
Agency Debt	0	Reverse repurchase agreements	29.7
Repurchase Agreements	39.8	Others	12.3
Direct Loans	1.3		
Gold	11.0	*Total liabilities*	*847.9*
Foreign reserves	20.5		
Other Assets	27.0		
Total Assets	*878.5*	*Capital*	*30.6*

***Panel B**. January, 2, 2009*

Federal Funds Target Range: 0 – 0.25%

Balance Sheet (in billions of dollars)

Assets		**Liabilities**	
Securities held outright			
U.S. Treasury bills	18.4	Federal Reserve notes	853.2
U.S. Treasury notes and bonds	457.5	Commercial bank reserves	860.0
Agency debt	19.7	U.S. Treasury deposits	365.4
Repurchase Agreements	80.0	Reverse repurchase agreements	88.3
Direct Loans	193.9	Others	56.9
Gold	11.0		
Foreign reserves	579.8	*Total liabilities*	*2223.8*
Other assets	47.4		
New asset categories			
Term Auction Facility (TAF)	450.2		
Commercial Paper FF	334.1		
Maiden Lane	73.9		
Total Assets	*2265.9*	*Capital*	*42.2*

***Panel C**. August, 20, 2009*

Federal Funds Target Range: 0 – 0.25%

Balance Sheet (in billions of dollars)

Assets		**Liabilities**	
Securities held outright			
U.S. Treasury bills	18.4	Federal Reserve notes	871.5
U.S. Treasury notes and bonds	717.7	Commercial bank reserves	818.8
Agency debt	111.8	U.S. Treasury deposits	240.2
Repurchase Agreements	0	Reverse repurchase agreements	68.4
Direct Loans	106.3	Others	14.4
Gold	11.0		
Foreign reserves and other assets	76.7	*Total liabilities*	*2013.3*
New asset categories			
Term Auction Facility (TAF)	221.1		
Commercial Paper FF	53.7		
Maiden Lane	61.7		
Mortgage-backed securities	609.5		
Central Bank liquidity swaps	69.1		
Total Assets	*2063.8*	*Capital*	*50.5*

Sources: Board of Governors of the Federal Reserve System, Table H4.1 and Federal Reserve Bank of New York Quarterly Report on foreign exchange operations.

Figure 4. Agents and markets in the model of credit frictions

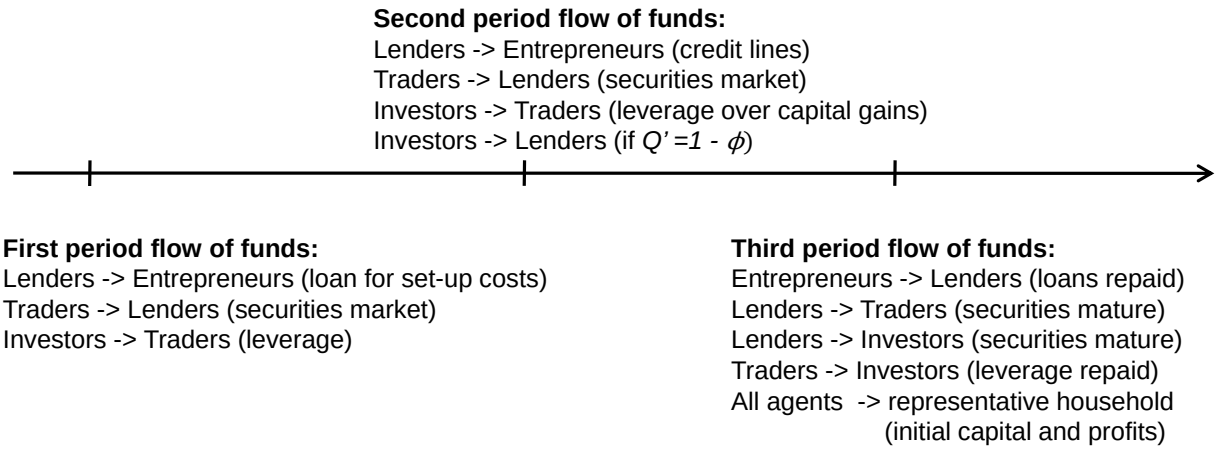
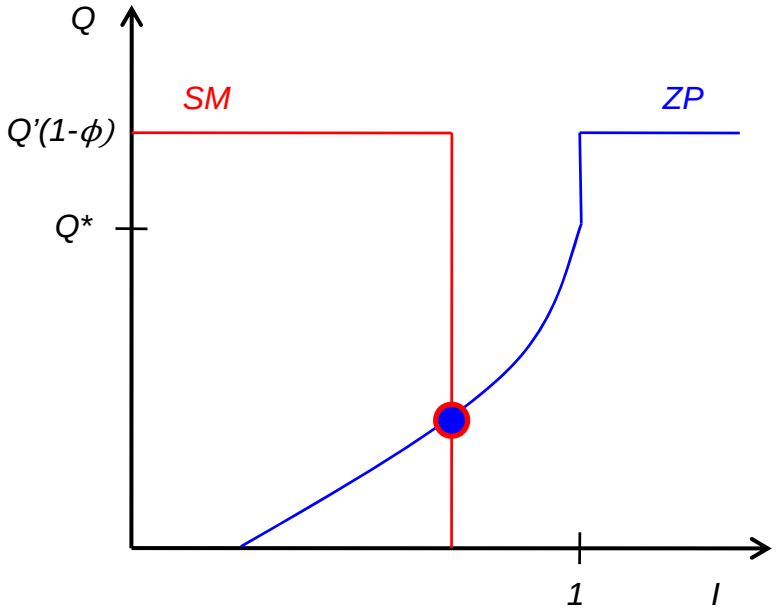


Figure 5. Equilibrium in a constrained economy

Top panel: First-period market



Bottom panel: Second-period market

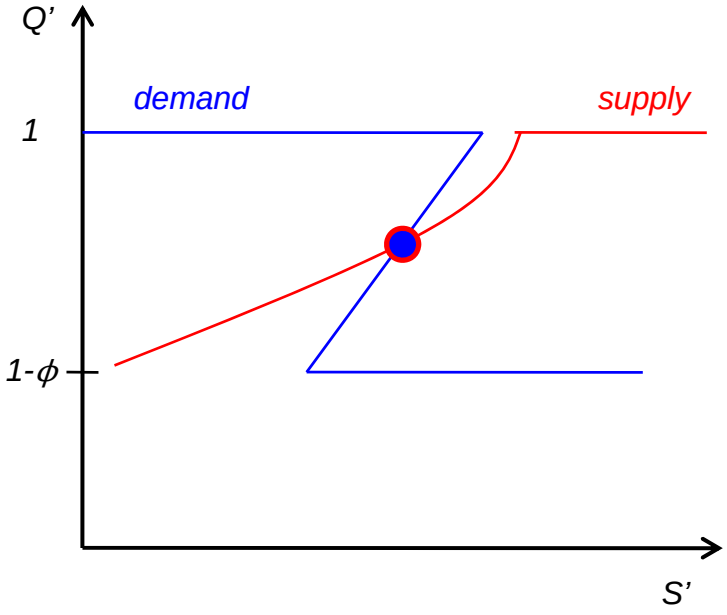
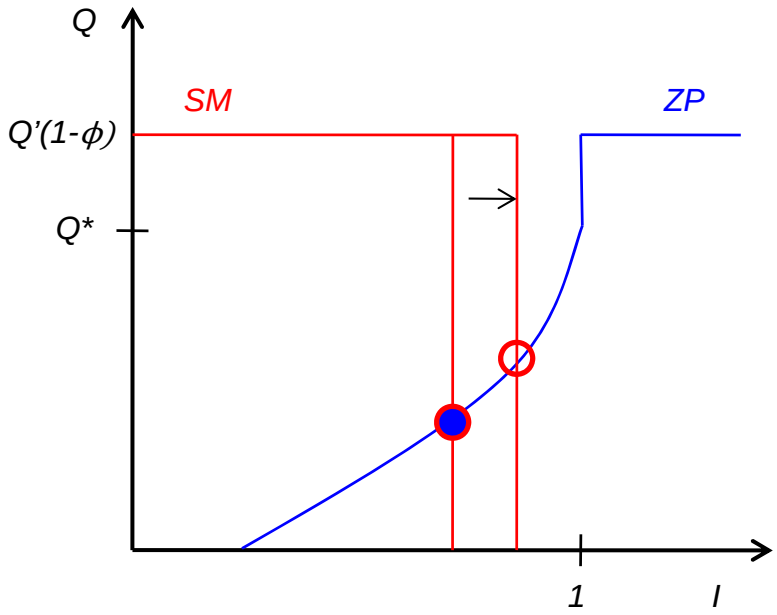


Figure 6. Injecting credit via loans to lenders and traders (first-round effects)

Top panel: First-period market



Bottom panel: Second-period market