Editor's Note

The papers in this special volume of the *Economic Policy Review* all focus on the theme of a 2009 conference on central bank liquidity tools organized by the Federal Reserve Bank of New York: the evaluation of central bank programs implemented to address funding shortages in the markets. Indeed, readers interested in detailed summaries of the conference papers and their discussions will find the overview by Matthew Denes and his coauthors very informative.

Two of the papers presented at the conference are included in this volume: the studies by Stephen G. Cecchetti and Piti Disyatat and by Erhan Artuç and Selva Demiralp. Both papers examine the past actions of central banks in the financial crisis. Cecchetti and Disyatat consider the implications that recent financial developments may have for the fundamental nature of central banks' lender-of-last-resort function and whether the traditional tools at policymakers' disposal remain effective in the face of modern liquidity crises. Artuç and Demiralp investigate whether changes to the Federal Reserve's discount window borrowing facility represent a fundamental shift in the way the Fed traditionally provided liquidity through the primary credit facility as well as whether the Fed would be well served to retain these changes to its borrowing facility indefinitely. A third paper, submitted separately for this volume, also addresses the role of central banks during the financial turmoil. Asani Sarkar and Jeffrey Shrader examine the Federal Reserve's recent actions in terms of the financial amplification literature.

Three other papers, solicited for this volume, broaden the discussion by providing perspectives on the future course of financial policy in the post-crisis era. Matthew Pritsker offers a theoretical view on the important topic of how regulators can improve the availability of information; Viral V. Acharya, João A. C. Santos, and Tanju Yorulmazer analyze ways to incorporate systemic risk into deposit insurance premiums; and John Geanakoplos discusses implications of the leverage cycle—whereby leverage is excessive prior to the crisis and too low during the crisis—for regulatory policy and reform.

We hope you enjoy the rich perspectives offered in this special volume of the *Review*.

—The *Economic Policy Review* Editorial Board

Central Bank Liquidity Tools

A Conference Sponsored by the Federal Reserve Bank of New York
February 19-20, 2009

Agenda

Thursday, February 19

8:45 a.m. — Opening Remarks
Patricia C. Mosser, Federal Reserve Bank of New York

9:00 a.m. — Session 1: Overview of Recent Problems in Liquidity Provision
Chair: *Tobias Adrian, Federal Reserve Bank of New York*

Central Bank Tools and Liquidity Shortages
Stephen G. Cecchetti, Bank for International Settlements
Piti Disyatat, Bank for International Settlements
Discussant: *Bengt Holmstrom, Massachusetts Institute of Technology*

10:30 a.m. — Session 2: Funding Liquidity and Market Liquidity
Chair: *Til Schuermann, Federal Reserve Bank of New York*

Leverage, Moral Hazard, and Liquidity
Viral V. Acharya, New York University and London Business School
S. "Vish" Viswanathan, Duke University
Discussant: *Patrick Bolton, Columbia University*

Interbank Market Liquidity and Central Bank Intervention
Franklin Allen, University of Pennsylvania
Elena Carletti, European University Institute
Douglas Gale, New York University
Discussant: *Adriano A. Rampini, Duke University*

Bank Liquidity, Interbank Markets, and Monetary Policy
Xavier Freixas, Universitat Pompeu Fabra
Antoine Martin, Federal Reserve Bank of New York
David Skeie, Federal Reserve Bank of New York
Discussant: *Franklin Allen, University of Pennsylvania*

2:00 p.m. — Session 3: Policy Responses to Illiquidity
Chair: *James J. McAndrews, Federal Reserve Bank of New York*

Illiquidity and Interest Rate Policy
Douglas W. Diamond, University of Chicago and National Bureau of Economic Research
Raghuram G. Rajan, University of Chicago and National Bureau of Economic Research
Discussant: *Guido Lorenzoni, Massachusetts Institute of Technology*

Liquidity Hoarding and Interbank Market Spreads: The Role of Counterparty Risk
Florian Heider, European Central Bank
Marie Hoerova, European Central Bank
Cornelia Holthausen, European Central Bank
Discussant: *Gaetano Antinolfi, Washington University*

Agenda

Thursday, February 19 (*Continued*)

3:40 p.m. — Session 4: Collateral and Haircuts

Chair: *Simon M. Potter, Federal Reserve Bank of New York*

Rollover Risk and Market Freezes
Viral V. Acharya, New York University and London Business School
Douglas Gale, New York University
Tanju Yorulmazer, Federal Reserve Bank of New York
Discussant: *Michael Manove, Boston University*

Central Bank Haircut Policy
James Chapman, Bank of Canada
Jonathan Chiu, Bank of Canada
Miguel Molico, Bank of Canada
Discussant: *Mitchell Berlin, Federal Reserve Bank of Philadelphia*

6:00 p.m. — Keynote Address

John Geanakoplos, Yale University

Agenda

Friday, February 20

9:00 a.m. — Session 5: Empirical Evaluation of Central Bank Liquidity Programs—Part I

Chair: *Seth B. Carpenter, Board of Governors of the Federal Reserve System*

Do Central Bank Liquidity Facilities Affect Interbank Lending Rates?
Jens H. E. Christensen, Federal Reserve Bank of San Francisco
Jose A. Lopez, Federal Reserve Bank of San Francisco
Glenn D. Rudebusch, Federal Reserve Bank of San Francisco
Discussant: *Pierre Collin-Dufresne, Columbia University*

Repo Market Effects of the Term Securities Lending Facility
Michael Fleming, Federal Reserve Bank of New York
Warren Hrung, Federal Reserve Bank of New York
Frank Keane, Federal Reserve Bank of New York
Discussant: *Lasse H. Pedersen, New York University*

Agenda

Friday, February 20 (*Continued*)

10:40 a.m. — Session 6: Empirical Evaluation of Central Bank Liquidity Programs—Part II

Chair: *James Vickery, Federal Reserve Bank of New York*

Funding Liquidity Risk: Definition and Measurement
Mathias Drehmann, Bank for International Settlements
Kleopatra Nikolaou, European Central Bank
Discussant: *Marie Hoerova, European Central Bank*

Provision of Liquidity through the Primary Credit Facility during the Financial Crisis: A Structural Analysis
Erhan Artuç, Koc University
Selva Demiralp, Koc University
Discussant: *Carolyn Wilkins, Bank of Canada*

1:15 p.m. — Panel Discussion

Chair: *Patricia C. Mosser, Federal Reserve Bank of New York*

Panel:
Louis Crandall, Wrightson ICAP
Andrew W. Lo, Massachusetts Institute of Technology
Paul Mercier, European Central Bank
Lasse H. Pedersen, New York University
W. Alexander Roever, J.P. Morgan Chase

Patricia C. Mosser

Conference Opening Remarks

Welcome to the Federal Reserve Bank of New York, and thank you for coming to this conference on central bank liquidity tools.

As acting manager of the Federal Reserve's System Open Market Account (SOMA), I am responsible for reporting to policymakers on the implementation of monetary policy in pursuit of the objectives that they have set. This includes the ways in which the Fed's balance sheet is being used as well as the ways in which financial conditions are impacting both the stance of monetary policy and its transmission to credit markets. In recent months, of course, this has also included the impact of what some have called our "alphabet soup" of liquidity facilities and programs.

I am very pleased to lead off this conference—the first of many conferences, I am sure—on central bank liquidity tools. When the organizers put this conference together many months ago, we knew there would be much to talk about. Little did we know that the number of liquidity tools and the depth of the financial crisis would continue to expand and to challenge us in the intervening months.

The expansion of the Fed's liquidity tools has been nothing short of extraordinary. In normal times, we essentially use four tools to manage the SOMA portfolio: temporary open market operations (OMOs), permanent OMOs, the discount window, and securities lending. By March 2008, when this conference was organized, we had nine tools; now, if we include the Term Asset-Backed Securities Loan Facility (TALF) and our new purchase programs, we have sixteen according to my count.

We tend to group the Fed's liquidity tools into three broad categories. In the first group, we have facilities that provide term liquidity to financial institutions—particularly to large, systemically important ones. These exist to reduce the systemic risk associated with the inability of a financial institution to get wholesale funding, which could in turn lead to a widespread deleveraging cycle involving forced asset sales that would ultimately become self-reinforcing, particularly for the largest financial institutions. In short, these facilities exist to forestall runs. These include the Term Auction Facility (TAF), foreign central bank swap lines, and the Primary Dealer Credit Facility (PDCF).

In the second group, we have facilities that provide liquidity directly to borrowers and lenders in key credit markets to prevent further declines in credit formation. These include the TALF, the Commercial Paper Funding Facility (CPFF), and the Money Market Mutual Fund Investor Funding Facility (MMIFF).

In the third group, we have programs involving the direct purchase of assets, particularly housing-related ones. These include our purchases of agency debt and mortgage-backed securities (MBS).

It is no accident that the Fed started with the first group in the early stages of the crisis. When this conference was organized, the Fed was addressing the crisis by rearranging its balance sheet, expanding lending programs, and reducing its holdings of Treasury securities. Many of the papers in this conference directly address the use of these types of tools and their links to funding and market liquidity issues.

Patricia C. Mosser is a senior vice president at the Federal Reserve Bank of New York; she was acting manager of the Federal Reserve's System Open Market Account at the time these remarks were delivered.

Among the many issues that we are hoping this conference will address are: What has the current crisis taught us about the use and effectiveness of traditional and new liquidity tools? To what extent might the expanded toolkits of central banks be useful for policy implementation in normal circumstances? Which tools are better kept as extraordinary measures?

Of course, last fall the balance-sheet constraints of large financial firms and funding pressures became a full-blown financial crisis with seriously impaired credit formation, a deep recession, capital assistance to large banks, and a significant feedback loop between financial and macroeconomic weakness. In response, the Fed has begun to use the asset side of its balance sheet to affect credit provision directly in key markets, such as those for commercial paper and MBS. To the extent possible, the Fed attempts to do this in a way that improves market functioning and liquidity, in order to set the stage for the private sector to return in the future. As a result, our balance sheet has ballooned with the expansion of both the size and number of our programs—our alphabet soup.

But a policy of credit easing in the currently very extreme situation raises a host of questions that I encourage everyone here to pursue in future research. Among these are: How can we measure the effectiveness of such policies? In Chairman Bernanke's terminology, "How should the central bank think about the impact and stance of monetary policy when pursuing a policy of credit easing?" How does one think about the size of the central bank's balance sheet? For example, some of the Fed's facilities are designed to expand when credit and market conditions deteriorate sharply, and to contract when conditions improve. During the last few weeks, for instance, the swaps program decreased by $150 billion.

As I mentioned at the outset, this will certainly not be the last conference on this topic. It is fair to say that economists, central bankers, and historians will be analyzing this financial crisis and the policy responses to it for decades to come. Nonetheless, we here at the Federal Reserve Bank of New York—who sometimes feel we are in the trenches every day—appreciate the insights that this conference can provide, preliminary though they may be. Because we are so close to many of these programs, we also appreciate the distance and perspective that your research can give. We particularly look forward to your future work in this area. I am guessing that central banks have provided you with a rich research agenda.

Again, welcome, and thank you for coming.

Matthew Denes, Daniel Greenwald, Nicholas Klagge, Ging Cee Ng,
Jeffrey Shrader, Michael Sockin, and John Sporn[1]

Conference Overview and Summary of Proceedings

1. Introduction

The financial crisis that emerged in 2007 had many and varied causes, but one of its most consistent themes has been the disappearance of liquidity. Indeed, in one of the first manifestations of the crisis in August 2007, BNP Paribas announced that it would suspend redemptions from three hedge funds, noting that a "complete evaporation of liquidity in certain market segments of the U.S. securitization market" had made it impossible to value the funds' assets. Since then, much economic policymaking has been devoted to understanding and combating liquidity shortages.

Although the crisis began less than two years ago, a significant body of academic work has already attempted to understand and address its causes and symptoms. Indeed, in February 2009, the Federal Reserve Bank of New York organized a Central Bank Liquidity Tools Conference to bring together some of the world's leading experts on liquidity to present their work and discuss its relevance and significance in the context of the ongoing crisis. While the papers considered a variety of topics, three critical and related questions unified the discussions: How do we define and understand liquidity? What are the causes and consequences of illiquidity? And what is the proper regulatory response to issues of liquidity?

One goal was to set out a clear definition of liquidity and to distinguish between different interpretations of the term. In particular, there is "market liquidity," which involves the readiness with which firms can buy or sell assets; "funding liquidity," which involves the ability of firms to obtain funding quickly and easily; and "central bank liquidity," which involves the ability of banks to easily borrow and lend reserve balances at the central bank. Although each of these types of liquidity is distinct, they are closely linked, and problems with one can quickly cause problems with the others.

A second goal was to examine the causes and consequences of liquidity shortages. Shocks to liquidity can be exacerbated, perpetuated, and spread because of financial market frictions such as balance-sheet constraints and the maturity mismatch between assets and liabilities, potentially leading to difficulties in rolling over sources of funding. In examining the consequences of illiquidity, many academics have made reference to traditional models of bank runs, updating them to account for the greater complexities of the modern financial system. Another common thread in the recent literature is the issue of systemic risk, whereby financial market illiquidity can turn firm-specific problems quickly into system-wide problems.

A third goal was to determine how central banks can best respond to these problems. Common issues of concern included the relative merits and effectiveness of ex ante policy (addressing causes) and ex post policy (addressing consequences), the need to define and measure policy goals in the absence of a single clear target such as the overnight rate, and the proper scope of financial regulation in a system where there are many major players outside the traditional banking sector.

Ultimately, all of the papers presented sought to answer a common question: What is the new "normal"? There is a broad consensus that the post-crisis financial system will not look like the pre-crisis system, as market participants and regulators adjust to the issues raised by the present crisis. Because illiquidity has played a key role in the crisis, an answer to this

[1] Introduction and panel discussion: Klagge; Session 1: Denes; Session 2: Sporn; Session 3: Greenwald; Session 4: Sockin; Session 5: Ng; Session 6: Shrader.

Nicholas Klagge is a financial analyst and Ging Cee Ng, Michael Sockin, and John Sporn are assistant economists at the Federal Reserve Bank of New York; Matthew Denes is a former research associate and Daniel Greenwald and Jeffrey Shrader are former assistant economists.
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question requires us to develop a better understanding of the nature of illiquidity, the role of illiquidity in the financial system, and the most effective policy responses to illiquidity.

2. Session 1: Overview of Recent Problems in Liquidity Provision

Paper:
"Central Bank Tools and Liquidity Shortages"
Stephen G. Cecchetti, Bank for International Settlements
Piti Disyatat, Bank for International Settlements

Discussant:
Bengt Holmstrom, Massachusetts Institute of Technology

Cecchetti and Disyatat examine the role of central banks as lenders of last resort. They distinguish three types of liquidity: central bank liquidity, market liquidity, and funding liquidity. Central bank liquidity consists of deposits from financial institutions at a central bank, which are often called reserve or settlement balances. Market liquidity is the ability of market participants to buy and sell assets in relatively large quantities without significantly influencing their market price. Funding liquidity is the ability of an individual or institution to raise cash by selling assets or borrowing.

Motivated by the definitions of liquidity, the authors describe three kinds of liquidity shortages. The first is a shortage of central bank liquidity, which occurs when institutions find themselves short of the reserve balances that they wish to hold. This shortage can be caused either by insufficient aggregate supply of reserves or by problems related to their distribution, and is not directly related to the solvency of individual institutions. The second type is an acute shortage of funding liquidity at a specific institution. This occurs when an institution is unable to raise funds to meet its short-term obligations, and is typically associated with solvency concerns. The third type of liquidity shortage is a systemic shortage of funding and market liquidity. This is potentially the most harmful kind of liquidity shortage, and it arises when coordination failures and an evaporation of confidence among market participants lead to a breakdown of key financial markets that affect many institutions simultaneously.

As a lender of last resort, a central bank has two main liquidity tools: open market operations and institution-specific transactions. In open market operations, a central bank lends and borrows or buys and sells assets outright in the open market. In addition, a central bank may also deal with specific institutions in order to channel liquidity directly to them.

The authors go on to examine the use of the two main liquidity tools to address each type of liquidity shortage. If there is a shortage of central bank liquidity, the primary aim of central bank intervention is to maintain the smooth functioning of the payments system and keep interest rates near their targets. This is generally accomplished by open market operations when aggregate supply shortages occur and through discount window lending directly to specific institutions when distribution problems arise. When a central bank is confronted with an acute shortage of funding liquidity at a specific institution, central bank support is designed to contain potential contagion and spillover effects to the rest of the financial system, hence forestalling an institution-specific problem from becoming a systemic one. The response typically takes the form of bridge financing in order to allow the institution time for restructuring. In such situations, the central bank must tactfully handle communication challenges to support confidence while staving off panic. Finally, in the face of a systemic shortage of funding and market liquidity, the immediate objective of central bank intervention is to restore market functioning and shore up confidence in the financial system as a whole. This is likely to entail the broad provision of liquidity to institutions as well as to specific markets.

In the current crisis, central banks have taken four major steps to stem systemic shortages of funding and market liquidity. First, they are providing backstop financing to financial institutions. Second, central banks are supporting term funding by lengthening the maturity on refinancing operations and establishing swap lines between central banks. Third, they are lending high-quality liquid securities against lower quality, less liquid securities in an effort to bolster markets for the latter and ease collateral constraints more generally. Fourth, central banks are supplying credit to the nonbank sector directly. These actions have significantly increased the size of the balance sheets at many central banks, including the Federal Reserve, the Bank of England, and the European Central Bank (ECB).

Overall, Cecchetti and Disyatat conclude that the traditional view of lender of last resort, as originally expounded by Walter Bagehot, requires modification. Significantly, the appropriate principles of lender-of-last-resort support by central banks must be conditioned on the particular type of liquidity shortage that is taking place. Moreover, given the complexities of the modern financial system, with large interdependencies between financial institutions and markets, the lender of last resort may need to act to support not only institutions, but certain markets as well.

Holmstrom—Cecchetti and Disyatat's discussant—drew lessons from the crisis on the relative merits of liquidity provision and risk sharing. He motivated his remarks by discussing issues of

aggregate risk sharing, high demand for secure, liquid debt, and the role of government in supplying and managing liquidity. He began by noting that even though the originate-and-distribute model may have led to weaker incentives to supervise lending standards and tranching of mortgages, where risk is spread to many investors, one should not jump to the conclusion that the model is fundamentally flawed.

Holmstrom argued that lack of transparency is a significant problem now, but that it is a standard, even essential, feature of liquidity provision. A traditional bank has never been transparent; there is no mark-to-market accounting and the balance sheet is quite opaque. In analyzing the nature of liquidity provision, it is important to recognize the high velocity of credit markets, a feature that prevents investors from evaluating the creditworthiness of investments. Such an evaluation requires that agents have symmetric information about the value of the instruments they are trading. The natural way to achieve this is to create information-insensitive instruments, such as debt, where agents rely on coarse ratings rather than detailed information about the assets supporting the debt. Securitization and limited transparency are logical steps to reduce information intensity.

The current crisis has been spurred by the symbiotic relationship between excess foreign demand for savings and demand for subprime loans. However, while the originate-and-distribute model has the ability to distribute systemic risk, it is now apparent that this risk was not always distributed to those who wanted to bear it and was in many cases held by liquidity providers. The distribution of systemic tail risk is the major flaw in the system, and it arises because systemic risk is not appropriately priced into liquidity-providing markets. This is a major challenge going forward. The government also has a role in providing insurance against systemic risk by injecting liquidity when there are large negative aggregate shocks. Public insurance is more efficient than private insurance for rare events, since the government can insure ex post, while private markets have to arrange insurance ex ante.

Holmstrom concluded by observing that, in an ideal world, all idiosyncratic risk would be eliminated through diversification and systemic risk would be borne by everyone in proportion to their risk tolerance. No crisis would ever occur in that case. The reality is far from this ideal, because information and incentive problems lead to an enormous demand for riskless debt. Though the originate-and-distribute model could be a step toward the ideal, and it has been useful in the industry, the problem with systemic tail risk needs to be resolved. As part of the solution, there should be a greater focus on regulation of leverage, as well as maturity mismatches.

One participant asked if it was logical for central banks to charge lower haircuts than the market does. Holmstrom responded that his presentation focused on redistribution of aggregate risk and did not incorporate information on haircuts.

Another asked how to overcome issues of adverse selection in the securities markets. Holmstrom noted that new innovation has failed to get beyond this problem. Cecchetti mentioned that the originate-and-distribute model allows the provider to keep good assets while selling off bad ones. The same participant observed that private providers are not ideal for offering insurance for catastrophic events. Holmstrom indicated that there is some scope for private insurance, but also for government insurance. Cecchetti added that this insurance cannot be supplied by private entities at a reasonable price.

The last question related to why over-the-counter markets have been disrupted. Cecchetti said he felt that most securities should be forced onto exchanges. A standardized market structure would be much more resilient.

3. Session 2: Funding Liquidity and Market Liquidity

Papers:

"Leverage, Moral Hazard, and Liquidity"
Viral V. Acharya, New York University
and London Business School
S. "Vish" Viswanathan, Duke University

Discussant:
Patrick Bolton, Columbia University

"Interbank Market Liquidity and Central Bank Intervention"
Franklin Allen, University of Pennsylvania
Elena Carletti, European University Institute
Douglas Gale, New York University

Discussant:
Adriano A. Rampini, Duke University

"Bank Liquidity, Interbank Markets, and Monetary Policy"
Xavier Freixas, Universitat Pompeu Fabra
Antoine Martin, Federal Reserve Bank of New York
David Skeie, Federal Reserve Bank of New York

Discussant:
Franklin Allen, University of Pennsylvania

3.1 Acharya and Viswanathan

Acharya and Viswanathan address a phenomenon that appears during times of financial shock: the evaporation of liquidity. Liquidity was plentiful prior to the crisis, and the problem was not one of hoarding cash, but rather, which asset class would absorb the demand from yield-seeking investors. With the onset of the crisis, however, risk aversion swept through the financial sector. The authors argue that the short-term debt with which balance sheets had been financed was a possible contributor to the market freeze. Firms were dependent on the ability to raise or roll over short-term debt collateralized by assets, as well as short-term unsecured commercial paper. If firms faced liquidation risk, these assets would have to be sold at "fire-sale" prices that would be much lower than the assets' fair value. Moreover, the inability of firms to roll over their existing debt would place a high burden on their ability to cover liabilities, necessitating fire sales.

Acharya and Viswanathan present two possible explanations for the increasing amount of leverage firms carried. The first holds that the downward trend in volatility prior to the crisis—a phenomenon that has been called the "Great Moderation"—led to rapid growth and increased issuance of inexpensive debt. The second explanation centers on the notion of a "credit bubble" characterized by light regulation and risk taking among financiers. The paper provides a model capturing the first theory.

In the model, short-term rollover debt is an optimal form of financing and the risk-shifting problem tied to leverage limits the funding of financial institutions that are reliant upon trading. The model revolves around one parameter: the maximum borrowing allowable as a result of the ex post risk shifting.

The key result attempts to explain why adverse shocks preceded by a prosperous economy tend to be much more severe. The authors state that when times are good, borrowing is inexpensive and even firms with low capitalization levels can leverage themselves in the market. Thus, ex ante there are more firms that are highly leveraged in the financial sector when times are good, and as a result there is not much spare debt capacity ex post in the event of a financial crisis. Only firms that are not highly leveraged during prosperous economic times have enough spare debt capacity to buy debt from other firms. Margin borrowing is usually very high during a prosperous economy, and as a result, prices are much lower during a subsequent crisis because once the adverse shocks materialize, there is a much deeper deleveraging in the economy. The asset substitution problem plays a key role, because it potentially rations firms when they are faced with the burden of raising cash. In such an environment, the only feasible option is to sell assets. The authors endogenize both the debt market and asset market and examine the implications for prices. They also argue that hard debt contracts and collateral requirements give lenders higher recoveries and raise prices, outcomes that make raising debt desirable ex ante.

In his discussion, Bolton related this topic to the theory of lending booms and liquidity crises. He summarized the Acharya-Viswanathan paper as follows: the main premise is that firms may engage in asset sales to meet debt obligations. The buyers of the assets, however, have limited purchasing power because of the liquidity shock. The prices are determined by supply and demand and by the distribution of leverage in the industry. In a boom, increasing profitability leads to lower demand for outside liquidity, which is followed by higher asset prices. Because of greater entry into the market of lower quality assets, however, there is a larger collapse in asset prices when a negative shock occurs. Bolton also commented on the fact that the model does not have any losers ex ante, and that liquidity crises involve no inefficiencies ex post.

3.2 Allen, Carletti, and Gale

Allen, Carletti, and Gale focus on the interbank market. They begin by explaining that under normal circumstances, the interbank market works smoothly. Under some circumstances, however, it ceases to function properly. As a result, central banks intervene in the market in an attempt to stabilize prices and correct market inefficiencies.

The paper develops a simple theoretical framework for analyzing interbank markets and how central banks should intervene through open market operations. Banks use the interbank market to hedge against idiosyncratic and aggregate liquidity shocks. Hedging opportunities are, however, limited and markets are incomplete. This implies that market allocations are inefficient, as they entail excess price volatility and thus consumption volatility across banks. This is the only market failure in the model. The authors show that, by conducting open market operations and fixing the interest rate in the interbank market, the central bank can implement the constrained optimal allocation, where all banks can offer the same consumption to their late depositors irrespective of the idiosyncratic liquidity shock they face. The central bank is coupled with a fiscal authority that imposes lump-sum taxes on (or provides transfers to) depositors to acquire the short (or long) asset at the initial date and can give a lump-sum transfer to (or impose a tax on) the later consumers at the final date. Allen, Carletti, and Gale show that the exact nature of central

bank intervention depends on the type of shocks banks face and on the initial contract that banks promise to their depositors.

Discussant Rampini observed that "market freezes" in the context of the paper manifest themselves through a lack of trade when all banks have excess liquidity and the central bank drains excess liquidity by selling the long asset. He considered this an interesting, albeit somewhat unconventional, notion of a market freeze. Rampini also argued that the central bank policy proposed encompasses aspects of fiscal policy, and that the paper might thus provide a guide to the possibility of monetary and fiscal policy working in conjunction during a financial crisis.

3.3 Freixas, Martin, and Skeie

The final paper, by Freixas, Martin, and Skeie, begins by examining the role of central bank policy in the face of crisis. One view maintains that the central bank should focus on inflation and output in the medium and long run and not respond to the crisis directly. However, in the past, central banks have aggressively lowered interest rates during crises.

During financial disruptions, banks usually face considerable uncertainty with regard to their demand for liquid assets. A state-dependent interest rate, which is low during times of shock and high during a strong economy, can help mitigate the risks associated with idiosyncratic shocks. The paper argues that monetary policy plays a crucial role in setting low interest rates to facilitate the redistribution of liquidity during a crisis.

In the authors' model, the interest rate in the interbank market plays an important role in two ways. Ex ante, high interest rates are beneficial because they ensure that banks hold enough liquid assets, as it is expensive to acquire such assets in the interbank market. Ex post, however, interest rates need to be low when an idiosyncratic shock hits to facilitate trading in the interbank market. Redistribution of liquidity and high levels of interbank risk sharing are now necessary for the banking sector. The main challenge for a central bank is to set the right balance between high expected rates ex ante and low rates ex post in times of crisis.

Allen's discussion first reviewed the authors' model and then showed its relationship to the traditional model of Diamond and Dybvig (1983). Allen also pinpointed the innovative addition to the new model: having two states with different idiosyncratic bank shocks. An important point was also raised on the issue of how the central bank should set interest rates. According to Allen, these models are very important because they are a building block for understanding the complexities surrounding both market failures and stability. In light of the crisis, these models can provide clarity and a possible course of government intervention.

4. Session 3: Policy Responses to Illiquidity

Papers:
"Illiquidity and Interest Rate Policy"
Douglas W. Diamond, University of Chicago and National Bureau of Economic Research
Raghuram G. Rajan, University of Chicago and National Bureau of Economic Research

Discussant:
Guido Lorenzoni, Massachusetts Institute of Technology

"Liquidity Hoarding and Interbank Market Spreads: The Role of Counterparty Risk"
Florian Heider, European Central Bank
Marie Hoerova, European Central Bank
Cornelia Holthausen, European Central Bank

Discussant:
Gaetano Antinolfi, Washington University

4.1 Diamond and Rajan

Diamond and Rajan investigate the relationship between interest rates and the incentives facing banks regarding illiquid investments. Their work contributes to the longstanding debate between those who believe, like Alan Greenspan, that the Federal Reserve cannot prevent asset price bubbles, only mitigate their consequences, and those who believe that asymmetric interest rate policy can encourage behavior that makes booms and busts more likely.

The authors create a model in which entrepreneurs who invest in long-term projects must borrow from banks that in turn borrow from risk-averse households. In the model, there is no uncertainty about the profitability of projects, which are predetermined, but there is uncertainty about the households' income in each period. Liquidity problems can emerge if households have an unexpectedly high need to withdraw deposits. This, they assert, can occur either because of an unexpected decrease in present income or an increase in expected future income. With a decrease in present income,

households face a higher marginal utility of consumption and may want to spend their financial assets in order to consume more today. If, however, households expect significantly higher income in the future, they may spend their assets today in order to smooth lifetime consumption.

In either case, unanticipated demand for funds can force banks to call in loans for long-term projects early. As a result, the real interest rate must rise in order to equalize household demand for consumption goods and the supply of consumption goods from terminated projects whose loans have been called in. This in turn decreases bank net worth, since a bank's loans, which pay off only in the long run, fall in value as the real interest rate rises, but the bank's liabilities of demandable deposits do not have a corresponding fall in value. If the bank's net worth becomes negative, the bank can experience runs, which can be highly inefficient when they cause the terminations of otherwise profitable projects financed by bank loans. Thus, an increase in households' withdrawals, owing either to a current decrease in income or to a future increase in income, can create fragility in the banking system that harms the real economy.

One solution to this problem would be to change the structure of banks so that they were less reliant on demandable deposits for funding. However, such a change would be very difficult, as Diamond and Rajan, citing their past work, note. The authors assert that demandable debt is the cheapest form of financing available to banks, and that using more long-term liabilities that are not demandable would reduce the efficiency of intermediation substantially. Changing the sources of banks' funds is therefore not viewed as a viable option to reduce fragility in the banking system.

Another option is to use government intervention to attempt to stabilize the banking system and prevent bank runs. As a first possibility, governments can intervene by taxing households and giving the proceeds directly to banks. But while such a bailout scenario could certainly be effective in preventing bank runs and might be necessary in times of crisis such as the present, Diamond and Rajan argue that the severity with which property rights are violated under these policies makes them unsuitable for frequent use.

Instead, they consider an alternative policy measure in which the government lends or borrows in the market in an attempt to alter interest rates, and apply this type of policy to their model. Diamond and Rajan first note that since government action must be financed by tax revenues, there are potential issues of Ricardian equivalence. If the government seeks to lower interest rates by lending funds, it must raise these funds by increasing taxes. When a household's taxes are raised, however, the household is likely to increase its withdrawals in order to make up for the current decline in income, as mentioned earlier, which would counterproductively push interest rates back up.

The authors' model shows that as long as the government finances its lending by taxing only households with deposits, with the level of deposits exceeding the size of the tax, there is zero effect on the interest rate. As a result, government intervention is likely to be ineffective when most or all households hold large amounts of demandable deposits relative to the size of the tax. However, if there are households that do not hold deposits, or if the level of the tax exceeds the amount of the households' deposit holdings, then the government action does have a marginal effect in the model, lowering the real interest rate and increasing banks' net worth. Thus, although households' actions in response to a government intervention may reduce its effectiveness, the intervention should still be effective, provided that it is large enough.

Next, Diamond and Rajan note while there can be benefits to influencing household and bank behavior if it prevents bank runs, it is also likely that altering these decisions can have negative effects. In the model, the authors consider both an "entrepreneur-friendly" central bank that seeks to lower interest rates as much as possible and a "household-friendly" central bank that seeks to raise interest rates as much as possible. They demonstrate that each type of central bank can have negative effects when its action is anticipated, even on the group that it attempted to benefit, owing to the distortions in behavior that it creates.

Finally, the authors argue that when government policy is anticipated, it can have an important impact on how banks choose to allocate their portfolios between liquid and illiquid investments. In the model, they assume that the government commits to lowering interest rates in case of liquidity problems and find that this encourages banks to take on more deposits and to finance more illiquid projects, making liquidity shortages more likely. As a result, they claim that commitment to a "one-sided" policy to intervene only to lower interest rates when they are too high can lead to distortions in bank decisions that can have a strongly counterproductive effect and make liquidity crises much more likely.

For this reason, Diamond and Rajan assert that an optimal interest rate policy must not only prevent bank runs by lowering interest rates in times of crisis, but also encourage banks to make more liquid loans to prevent distortion. To this end, the central bank should pursue a "two-sided" policy of interventions, in which the bank not only acts to lower interest rates to prevent runs when rates are too high, but also pushes interest rates up when the interest rate would otherwise be low. This type of intervention would punish illiquid banks, forcing them to call in loans and decreasing their net worth, but would not raise rates so much as to cause bank runs. Appropriately

implemented, this incentive against illiquidity could balance out the incentive in favor of illiquidity caused by the central bank's commitment to lower interest rates in times of crisis. Such a two-sided policy could therefore prevent distortions and allow banks to make an efficient allocation between liquid and illiquid investments while still allowing the central bank to intervene in order to prevent harmful bank runs.

Lorenzoni, in his discussion, offered an adaptation of the basic model presented by Diamond and Rajan. In the original model, a bank choosing to liquidate an entrepreneur's project must liquidate it entirely. Lorenzoni presented a model of partial liquidation, in which the bank can choose to terminate only part of a project early for an immediate payoff, leaving the rest to mature in the final period.

In this variation, the payoff that the bank gets for a project that is not completely liquidated is assumed to be a concave function that represents diminishing returns to the proportion of the original loan still invested in the project (that is, the proportion *not* liquidated). When this payoff is combined with terms representing the returns from liquidation and the cost of paying interest on deposits, a profit function for banks can be formed. First-order conditions can then be taken to find a bank's optimal policy with regard to liquidation. Lorenzoni found three possible regimes, depending on the interest rate: a no-liquidation regime at a low interest rate, a complete-liquidation regime at a high interest rate, and a partial-liquidation regime at an interest rate between the two extremes.

The discussant then created a supply function by optimizing consumers' utility with respect to the amount of funds loaned over the two periods and combines it with the demand function to find the market equilibrium. The result is that in an "exuberant" state, in which consumers' second-period endowments turn out to be very high, the equilibrium interest rate is also high, because consumers require larger incentives to transfer consumption from the first period to the second. If the equilibrium rate is high enough in this scenario, it can lead to a regime in which no lending takes place and banks go bankrupt and default on their debt as a result.

Lorenzoni incorporated the government into the modified model. The government taxes consumers and lends out tax revenues to banks. Once the loans are repaid, the government returns the tax revenues, plus interest, to the consumers. If consumers are free to optimize over any quantity of lending, including negative quantities (meaning that the consumers borrow from the banks), then households will simply adjust their lending to offset the tax. Government intervention therefore has no effect on the net supply of funds, which is independent of the size of the tax, and Ricardian equivalence holds. However, if a constraint is imposed that households may lend but may not borrow (that is, the amount of lending must be non-negative), then government intervention may have an effect on the interest rate. Specifically, if the size of the tax is larger than the supply of loans under the initial equilibrium so that consumers cannot simply decrease their lending to offset the tax, then such a policy will reduce market interest rates.

Lorenzoni then turned to the issue of the optimal choice of banks' initial short-term debt, from the standpoint of maximizing expected payment to customers. More debt increases the probability of inefficient bankruptcy, but also increases the payment to consumers in nonbankruptcy states. The optimal level of debt must therefore find an equilibrium that balances these two opposing forces in favor of the consumer.

The issue of moral hazard was also considered. Lorenzoni assumed that the government intervenes ex post to protect banks in the "exuberant" state. But if this can be expected ahead of time, the level of debt that banks will take on increases endogenously. It is also possible, Lorenzoni asserted, for this distortion to make all parties worse off, reinforcing the potential problems of government intervention posed by Diamond and Rajan in their original model.

Overall, the partial-liquidation version of the model adapted by Lorenzoni is consistent with the main findings of Diamond and Rajan. This is especially true regarding the benefits and dangers of interest rate interventions not driven by cyclical conditions. Therefore, the powerful ex ante effects of moral hazard and reverse moral hazard present in the initial version of the model are maintained under the assumption of partial liquidation.

4.2 Heider, Hoerova, and Holthausen

The session's second paper sought to explain the recent tensions and eventual breakdown in the unsecured interbank lending market in a number of countries around the world. Much more so than in the past, banks have been keeping liquidity on their accounts rather than lending excess funds on the interbank market. Authors Heider, Hoerova, and Holthausen identify this phenomenon as a clear failure of the interbank market to efficiently redistribute liquidity.

To explain these developments, they present a three-period model based on adverse selection caused by the asymmetric information between banks regarding the risk of illiquid assets. In the first period, banks must allocate their funds between a risk-free liquid asset and a risky illiquid asset. The liquid asset pays off in the next period exactly what was put into it, and is essentially a form of storage. The illiquid asset will either have a high return R if it succeeds, or a return of zero if it fails. The size of the return R is known and is the same for all banks. The

probability of success varies across banks, but is unknown to banks in the first period. It is assumed that the expected return from the illiquid asset is greater than 1, making it larger than the return to the liquid asset.

In the second period, banks face a "liquidity shock" in which either a small or large amount of deposits is withdrawn by consumers, which the banks must pay. Banks with a shortage of liquidity (large withdrawals) can borrow from other banks that have excess liquidity (small withdrawals), thus forming an interbank market. However, banks also receive private information as to whether their illiquid assets are riskier (with a lower probability of success) or safer (with a higher probability of success) than expected. If banks have a shortage of liquidity to pay depositors, they may drop out of the unsecured interbank market and convert their illiquid assets into liquidity at a cost. Riskier assets are more illiquid, so banks with safer assets have better opportunities to obtain (costly) funding outside the unsecured market.

In the third period, the illiquid assets either succeed or fail, and interbank loans are repaid when possible. Since the illiquid asset has zero return when it fails, interbank loans are not repaid when the borrower's illiquid asset does not succeed. This potential for default leads to counterparty risk in the interbank market.

The study focuses on the role of asymmetric information about counterparty risk in the functioning of the unsecured interbank market. Banks with a liquidity shortage have a choice between borrowing and converting their illiquid assets into liquidity at a cost. Since safer assets are more liquid than riskier assets, banks with safe assets will require a lower interbank interest rate than banks with risky assets to be willing to stay in the unsecured interbank market. If the interest rate is higher than what the safe borrowers are willing to pay, they will drop out of the market. However, the risky borrowers may still be willing to pay this higher interest rate, leading to a scenario of adverse selection.

Depending on parameters, reflecting in particular the level and distribution of counterparty risk among banks, three different equilibrium "regimes" can arise in the interbank market. Under the first regime, there is full participation in the interbank market, and banks do not need to resort to converting their illiquid assets into liquidity. This is typically the case when there are low levels of counterparty risk and thus low interbank interest rates, preventing adverse selection. Under the second regime, the interbank interest rate is high enough that the safe borrowers are no longer willing to participate. However, there is still a market to provide unsecured loans to risky borrowers willing to pay a higher interest rate. This is the regime in which adverse selection takes place.

In the third regime, the interbank market breaks down. This can occur for one of two reasons. In the first case, the banks with excess liquidity can refuse to lend, and "hoard" their liquidity instead. A necessary condition for this to occur is that the illiquid asset that turns out to be riskier than expected is unprofitable in expected value. Still, the ex ante expected return on the illiquid asset is positive and dominates the rate of return on the liquid asset. In the second case, banks with excess liquidity may be willing to make loans to the banks with risky assets, but the market interest rate may be so high that even the risky banks prefer to drop out of the unsecured interbank market.

Heider, Hoerova, and Holthausen then compare the results of their model with empirical evidence from the three-month unsecured interbank market in the euro area from July 2006 and January 2009. They argue that the interbank market did in fact exhibit the three regimes described above as both the perceived level and dispersion of risk associated with banks' illiquid assets rose. The authors first examine the spread between the three-month unsecured interbank rate in the euro area (Euribor) and the overnight index swap (OIS) in three months' time to show changes in the interbank interest rate. They also look at the use of the ECB's deposit facility, where banks can place their excess funds, but which offers a lower interest rate than does the interbank market, to demonstrate liquidity hoarding.

In the first phase, beginning in July 2006, the authors note both a very low spread and an insignificant utilization of the deposit facility, consistent with a "full-participation" regime. In the second phase, beginning in August 2007, the spread rises significantly, but the deposit facility is still used very rarely, which they argue is consistent with an "adverse selection" regime, in which only the "riskier" banks, lacking good-quality collateral to borrow in the repo market, are willing to pay such high interest rates in the unsecured interbank market. In the third phase, beginning in September 2008, the interest rate increases further, and use of the deposit facility increases dramatically, showing a breakdown of the interbank lending market and large amounts of hoarding behavior. The authors also show that a similar pattern of the three-month interbank market spread can be observed in the United States in the aforementioned time period.

Heider, Hoerova, and Holthausen conclude by identifying policy interventions that could reduce or prevent adverse selection and thereby increase the efficiency of the interbank market. These are divided into two types of interventions: ex ante policies to prevent a dropping out of the good risks from the unsecured market, and ex post policies to restore the effectiveness of the interbank market after an unexpected increase in counterparty risk.

On the ex ante side, the study offers two options: liquidity requirements and improved transparency. Under the liquidity requirements option, there would be a limit on the amount of illiquid assets that banks would be permitted to hold at any given time. This would generally provide banks with more liquidity, reducing the demand for liquidity in the interbank market. As a result, the interbank interest rate would fall, which would make all banks, particularly banks with safe assets, more willing to borrow. This outcome in turn would ensure the full participation of banks in the unsecured market and, consequently, its smooth functioning. The downside of such a policy is that with less of the illiquid assets held, banks would receive lower returns on average from their investments, because of distortions in banks' optimal portfolio allocation.

Under the improved transparency option, the government would work to make banks' private information about their portfolios more public. This could allow for banks with excess liquidity to distinguish between safe and risky lenders, and potentially offer different lending terms to each. It would prevent adverse selection, as safe banks with a liquidity shortage would no longer be pooled with riskier banks and could instead pay a lower rate that reflects the reduced counterparty risk taken on by the lending bank. Therefore, improved transparency could also facilitate interbank lending and reduce early liquidations.

On the ex post side, the authors present three policy alternatives for situations when interbank market functioning has already been impaired. First, the central bank can directly provide liquidity to banks. This, they argue, can be profitable for all parties involved, since the central bank can raise liquidity at a unit cost by "printing money," in contrast to the private supply of liquidity that must compete with the returns offered by the illiquid asset. By supplying liquidity to banks in need, the central bank could crowd out the private supply of liquidity. Heider, Hoerova, and Holthausen argue that as a result, the central bank could offer to take on liquidity from the banks with excess liquidity. In this case, the central bank would act as an intermediary in the interbank market.

A second option is for the central bank to guarantee interbank loans. This would reduce or eliminate counterparty risk and make banks with excess liquidity more willing to lend in the interbank market. It would in turn reduce the interbank interest rate, which would increase borrowing and potentially reduce adverse selection in the interbank market. However, such guarantees are costly and must be designed optimally to minimize the overall costs to the guarantor.

The third option is asset purchases, in which the government directly purchases illiquid assets from banks. Since the government can afford to purchase the assets at their expected value, this would prevent banks from having to sell at fire-sale prices, which occurs when the amount of illiquid assets being sold in order to convert them into liquidity exceeds the amount of liquidity available to purchase them. Such a measure would not increase interbank lending, and would in fact likely discourage it, but the measure would reduce the losses faced by banks that would otherwise have to sell assets at a price significantly below their expected value.

Antinolfi's discussion offered a number of avenues for further inquiry using Heider, Hoerova, and Holthausen's model. First, he examined the issue of the deposit arrangement within the model. The question was posed as to whether the deposit contract as specified is actually optimal, or if a better arrangement could be found. Antinolfi also considered the issue of deposit insurance. Whether deposit insurance is provided, how much is provided, and who pays for it could all have an important impact on outcomes in the model.

Next, Antinolfi considered the informational aspect of the model. The adverse selection in the model is entirely driven by private information held by banks about their assets that is not available to the public. Therefore, it is important to make sure that it is reasonable to assume that banks can in fact ascertain their own "type" while keeping it unknown to potential lenders.

Finally, the discussant suggested that the authors or future researchers look into the structure of the banking sector. The model assumes perfect competition, but it might yield different results under another arrangement, such as monopoly or oligopoly.

5. Session 4: Collateral and Haircuts

Papers:

"Rollover Risk and Market Freezes"
Viral V. Acharya, New York University
and London Business School
Douglas Gale, New York University
Tanju Yorulmazer, Federal Reserve Bank of New York

Discussant:
Michael Manove, Boston University

"Central Bank Haircut Policy"
James Chapman, Bank of Canada
Jonathan Chiu, Bank of Canada
Miguel Molico, Bank of Canada

Discussant:
Mitchell Berlin, Federal Reserve Bank of Philadelphia

5.1 Overview

A conference session on collateral and haircuts featured two papers examining the theoretical underpinnings of the market for secured short-term debt.[2] Many financial institutions rely on overnight or short-term secured lending to meet their liquidity needs and finance longer maturity assets. The counterparty in these loans is often a central bank or market participant such as a bank, a money market mutual fund, or an institutional investor. Collateral used to secure these loans can vary from Treasury and agency debt securities to corporate bonds, equities, and bank loans. To protect the lender from changes in the collateral's value, an initial discount, or "haircut," is applied to the value of the asset that can be borrowed against, hereafter referred to as the asset's debt capacity. The optimal choice of haircuts for central banks is the topic of the paper by Chapman, Chiu, and Molico while Acharya, Gale, and Yorulmazer explore changes in an asset's debt capacity when the debt must be rolled over.[3]

In the interbank market, secured lending takes the form of repurchase agreements, or repos.[4] Repos typically have a maturity ranging from overnight to fourteen days. A central bank can provide intraday liquidity to financial institutions through repos and, as Chapman, Chiu, and Molico suggest, affect the supply of liquidity in the market through its choice of haircuts. The authors develop a general equilibrium formulation for the optimal level of haircuts in the presence of agent liquidity constraints, liquidity shocks, and asset price volatility. Their model stipulates that haircuts are higher when a central bank cannot exclusively lend to agents with liquidity constraints, and that a sudden, temporary increase in haircuts can be welfare-improving.

Acharya, Gale, and Yorulmazer attempt to explain how markets for collateralized lending can fail as a result of rollover risk, the risk that short-term debt cannot be rolled over and the sponsoring institution will have to sell the underlying asset in a fire sale. By constructing a regime-switching model for how investors perceive expectations on news, the authors demonstrate how an asset's debt capacity can decline without a change in its fundamental value and raise the issuing firm's counterparty credit risk. This adverse event is equivalent to an increase in haircuts and can help explain the market dislocation observed in the asset-backed commercial paper market during the subprime mortgage crisis beginning in 2007.

As the discussion following each presentation highlighted, the issues of liquidity and risk management arising from maturity mismatch and market shocks in secured lending are nontrivial. Short-term financing ex ante with loans secured by assets whose fundamental value is not resolved until ex post creates uncertainty over ultimate payoffs endogenous to default and counterparty credit risk. Since the debt capacity of an asset can change over time, it is important to understand what drives these changes and how to manage the risks from both the borrower's and the lender's perspective. The inability to sufficiently manage these risks can lead to depreciation of both liquid and illiquid assets, unforeseen liquidity constraints, and catastrophic market failure. The papers presented draw attention to important considerations for regulators with regard to participation and intervention in these markets.

5.2 Acharya, Gale, and Yorulmazer

Acharya, Gale, and Yorulmazer examine how changes in investor expectations in secured short-term lending markets can lead to market freezes. The authors focus on the market for asset-backed commercial paper, where debt must be rolled over several times before the underlying asset matures and its value is realized. They construct a regime-switching model for two possible states of the world, denoted as the "optimistic" and "pessimistic" states (defined later), and explore how the debt capacity of an asset changes as debt is rolled over in each state. The study concludes that the debt capacity of an asset is determined by the terminal state, where it tends to its fundamental value if the state of the world is optimistic and zero if the state of the world is pessimistic. This last result can explain how short-term debt markets can freeze regardless of the credit risk of the underlying asset.

The authors interpret their model in the context of a special investment vehicle that finances an asset-backed security by issuing short-term debt that must be rolled over a finite number of times before the asset matures. There exist two states of the world for investor expectations: an optimistic state where "no news is good news" and a pessimistic state where "no news is bad news," which can switch with a fixed probability each period. In the optimistic state, by backward induction, the debt capacity increases with each rollover to match the asset's fundamental value. In the pessimistic state, similarly, the debt capacity tends to zero and leads to a market

[2] Secured lending differs from unsecured lending in that an asset with low credit risk is pledged by the borrower as collateral to be seized in the event of default. This form of lending allows an institution to borrow at more attractive interest rates with a debt ceiling not limited by its own credit risk.

[3] Since the maturity of short-term debt in commercial paper markets is often less than the maturity of the asset being financed, the debt must be reissued, or "rolled over," to new investors until the asset matures.

[4] In a repurchase agreement, the lender purchases the posted collateral at a discount and agrees to sell it back at a later date at a higher price that includes the interest on the loan.

freeze, wherein the sponsoring bank takes the asset back onto its balance sheet and sells it in a fire sale.

Based upon these results, the authors propose an explicit formula for collateral haircuts by solving for the pledged asset's debt capacity. As the number of rollovers becomes unbounded in the pessimistic state, haircuts tend to reach 100 percent as long as the recovery rate on the asset is less than full recovery. One policy implication of these results is that firm failure from market freezes can potentially be avoided if regulators monitor firm capital structure for excessive reliance on short-term debt that entails rollover risk. Another implication is that regulators could help thaw market freezes by lending against the asset as collateral based on its value if held to maturity without risk of liquidation.

The ensuing discussion centered on the results of the model's pessimistic state. As Manove observed, one implication is that removing risk of default in one period will not prevent default in future periods once the asset's debt capacity is on the default trajectory. While the paper showed that mismatching maturities by financing long-term investments with short-term debt can lead to market failure, Manove noted that using long-term debt to finance long-term investments lacked the benefits described in the Diamond-Dybvig (1983) model. In addition, reducing rollover risk by financing with more unleveraged equity would be less profitable than debt financing.

Examining the policy implications of the paper, participants discussed whether regulators could reduce liquidation costs by swapping assets for more liquid instruments in addition to lending against them at their value if held to maturity. Regulators could also limit leverage by requiring firms to maintain a minimum level of equity financing. Drawing parallels with the Diamond-Dybvig model, Manove also compared the market freezes described in the paper with bank runs. When one views short-term lenders as depositors and long-term assets as bank loans, a situation such as a market freeze in secured lending markets can be seen as analogous to a bank run. Consequently, if creating deposit insurance through the Federal Deposit Insurance Corporation (FDIC) helped prevent bank runs, establishing similar insurance in the secured lending markets could perhaps prevent market freezes.

5.3 Chapman, Chiu, and Molico

Chapman, Chiu, and Molico examine the optimal central bank haircut policy for the Canadian Large-Value Payment System. The authors develop a discrete-time three-market model for an illiquid and a liquid asset with anonymous agents that face portfolio allocation uncertainty. They find that central bank liquidity facilities provide insurance against both liquidity and downside asset risk, and that setting a haircut involves a trade-off between satisfying agent liquidity constraints and depreciation of the liquid asset. This depreciation can lead to portfolio distortions and increased probability of default on collateralized loans.

In the first subperiod of each period of the model, agents choose portfolios of the two assets in an asset market based on a signal as to whether they will be buyers or sellers in the second subperiod. In the second subperiod, agents reform portfolios based on the realization of their type in a decentralized market. This reformation can lead to liquidity constraints that agents satisfy with collateralized loans from the central bank. In the third subperiod, the illiquid asset's value is resolved and agents choose whether or not to settle their loans or default in a centralized market. The optimal choice for central bank haircuts on collateralized loans minimizes the incidence of default while providing financing to constrained agents.

The results of this model suggest that haircuts are higher when a central bank cannot identify which agents actually need liquidity. In addition, a relationship is established between collateral haircuts and the nominal interest rate, which is affected by the injection of the liquid asset into the market through collateralized loans. As haircuts are lowered, defaults create inflationary pressure by making this injection permanent. Lowering haircuts relative to the interest rate also erodes the liquid asset's value by making the illiquid asset less costly to hold.

Chapman, Chiu, and Molico's paper elicited discussion about the topic's relevance in the context of recent changes in central bank collateral policies brought on by the crisis. This included the expansion of the Federal Reserve's range of lending facilities and the European Central Bank's concern about accepting too wide a range of collateral. Berlin, leading the discussion, emphasized providing more empirical interpretation of the paper's assumptions and conclusion. He stipulated methods for measuring the relevant quantities in determining haircuts and reconsidering the assumption of endogenous default probability that can lead to strategic default.

From a policy perspective, participants discussed methods for refining collateral policies in light of the results of the paper. Berlin, for instance, suggested that discriminating between potential borrowers based on measures of liquidity or balance-sheet signals could potentially lead to a better outcome by effectively providing liquidity to constrained agents. He also introduced the possibility of charging higher borrowing rates to banks with more illiquid balance sheets and making loan payments contingent on investment returns to mitigate the impact of the liquidity injected into the system when defaulted assets are sold. Participants highlighted the paper's practical

implications in quantifying the impact of market forces driving haircut policy calibration.

6. Session 5: Empirical Evaluation of Central Bank Liquidity Programs—Part 1

Papers:

"Do Central Bank Liquidity Facilities Affect Interbank Lending Rates?"
Jens H. E. Christensen, Federal Reserve Bank of San Francisco
Jose A. Lopez, Federal Reserve Bank of San Francisco
Glenn D. Rudebusch, Federal Reserve Bank of San Francisco

Discussant:
Pierre Collin-Dufresne, Columbia University

"Repo Market Effects of the Term Securities Lending Facility"
Michael Fleming, Federal Reserve Bank of New York
Warren Hrung, Federal Reserve Bank of New York
Frank Keane, Federal Reserve Bank of New York

Discussant:
Lasse H. Pedersen, New York University

6.1 Christensen, Lopez, and Rudebusch

Lopez, presenting on behalf of coauthors Christensen and Rudebusch, examines the effects of central bank liquidity operations on interbank lending rates using an arbitrage-free term structure model that controls for fluctuations in the U.S. Treasury yield curve and the term structure of risk in financial corporate bond yields. The paper concludes that central bank liquidity operations at the close of 2007 helped to lower term interbank lending rates.

Motivating this paper were the large fluctuations in spreads of the three-month Libor (London interbank offered rate) over Treasury yields in mid-December 2007, when the Federal Reserve introduced two major liquidity operations: reciprocal swap lines with the European Central Bank and the Swiss National Bank, and the Term Auction Facility (TAF) program, whereby the Federal Reserve auctions collateralized loans to banks facing liquidity constraints. The goal of the Christensen, Lopez, and Rudebusch paper was to determine if these central bank policy actions helped increase bank liquidity, reduce liquidity risk premiums, and thus lower Libor rates.

Fluctuations in the spread of the three-month Libor over Treasuries are commonly attributed to movements in credit and liquidity risk premiums. The authors account for credit risk premiums by using the entire Treasury curve to control for risk-free rates and the term structure of financial corporate debt to control for credit risk premiums. In practice, Treasury bonds are considered free from credit risk and the most liquid debt instrument available. The key assumption for the latter is that Libor rates have credit risk characteristics similar to senior, unsecured AA-rated debt issued by U.S. financial firms. Controlling for credit risk allows the authors to isolate movements attributable to liquidity risk premia in interbank lending rates.

The authors use a six-factor affine arbitrage-free joint model of Treasury yields, financial bond yields, and Libor rates. The Treasury yield curve accounts for three factors: the level, slope, and curvature. Since movements in Treasury, bank bond, and Libor rates all share common elements, two of the remaining factors account for differences between bank debt yields and Treasuries (levels, slope). The last factor captures the idiosyncratic nature of term Libor rates, which the authors assume is independent of the other five factors.

The model specification draws on four major assumptions. The first is that the Libor-specific factor is independent of the other factors. The second is that the Treasury level factor is independent and has no dynamic interaction with the two credit spread risk factors. The third assumption allows the Treasury level and curvature factors to individually affect the Treasury slope factor, but not each other. The fourth posits that there is no feedback from the credit risk level factor to the Treasury curvature factor or from the credit risk slope factor to the Treasury slope factor. The likelihood ratio test on the specification with the independent Libor factor results in a failure to reject the null hypothesis that these additional zero restrictions are reasonable.

The paper presents three major results from the preferred model specification. First, the persistence of shocks was generally quite high, although much less for the Libor-specific factor. Second, the effects of Treasury factors on credit risk factors seem limited. Third, credit risk factors do have an influence on Treasury slope and curvature factors.

The presentation focuses on results that had implications for the interbank market. The estimated Libor-specific factor had been relatively stable around its historical mean in the pre-crisis period, but dropped more than two standard deviations below its mean after the first TAF auction on December 17, 2007. To test the hypothesis that this drop represented a structural break in the Libor factor, the authors use the Kalman filter and impose different parameters in the pre and post periods, at December 21, 2007. The likelihood ratio test rejects

the null hypothesis that no break occurred. The authors find that the data support the conclusion that central bank liquidity operations had an effect on the Libor-specific factor after the first TAF auction had taken place.

Lastly, the authors consider the counterfactual situation—what if the central bank effects on the Libor-specific factor were "turned off"?—to determine the magnitude of the effect of central bank liquidity operations. They generate a counterfactual Libor path by setting the Libor-specific factor constant at its mean after December 21, 2007. The average difference between the observed and counterfactual three-month Libor spread to Treasuries in the post-crisis period is more than 70 basis points. This provides additional evidence suggesting that central bank liquidity operations lowered interbank lending rates.

In conclusion, the authors find that the results from their six-factor model demonstrated that the TAF auctions significantly affected the dynamics of the interbank market via the structural break in the behavior of the model-implied Libor factor, and that these operations kept the Libor rate roughly 70 basis points lower than it could have been in their absence.

Discussant Collin-Dufresne questioned the assumptions and methodology of the paper. He wondered what was driving the difference between Libor and AA-rated bank yields and how various possible explanations would influence interpretation of the results.

Collin-Dufresne also questioned whether an affine model was well suited for a regime shift since affine models tend to need a lot of data. Given that much of the activity was found in the second half of the sample, he wondered if the model would have picked up a structural break at any point in the second half, and how intrinsically significant the post-TAF date was compared with other dates in the post-crisis period (that is, if causality could be established between the TAF and the regime shift). In addition, he conjectured a regime shift in the underlying Treasury rates, implying that the graph of the agency-Treasury spread may represent anticipation in the market.

6.2 Fleming, Hrung, and Keane

Fleming presented on behalf of coauthors Hrung and Keane. The presentation focused on the effects of the Term Securities Lending Facility (TSLF), introduced by the Federal Reserve in March 2008 to improve liquidity in the financing markets for Treasury and other collateral. In particular, the paper examines the supply effects of the program on rates and spreads in the repurchase agreement (repo) market. The authors find that the TSLF led to a significant narrowing of spreads between Treasury (higher quality) collateral and lower quality collateral.

The Federal Reserve introduced the TSLF in the midst of turbulent financial markets to help promote the liquidity of secured funding markets. The program auctions loans of Treasury securities to primary dealers for a period of twenty-eight days in exchange for lower quality collateral that, owing to stressed market conditions, would otherwise be difficult or unattractive to finance. The TSLF thereby increases the ability of dealers to obtain financing, especially dealers relying on the repo market for financing of less liquid collateral.

In addition to improving dealers' financing capacity, the TSLF can potentially affect rates in the repo market by altering collateral supplies. By allowing dealers to swap lower quality collateral for Treasury securities, the TSLF increases the supply of Treasury collateral in the market and decreases the supply of lower quality collateral. The additional Treasury collateral available to the market is hypothesized to put upward pressure on Treasury general collateral repo rates while the reduction in lower quality collateral is hypothesized to put downward pressure on repo rates for such collateral.

The data examined by the authors cover all thirty-seven TSLF operations from March 27, 2008, to October 30, 2008. The authors also use repo rates for Treasury securities, agency debt securities, and agency mortgage-backed securities (MBS) from the Federal Reserve Bank of New York's Trading Desk and Bloomberg. Additional data employed include Treasury issuances/redemptions and corporate yield spreads.

Fleming, Hrung, and Keane regress changes in overnight repo rates and spreads on changes in the amount outstanding under the TSLF. They focus on settlement days because TSLF-induced changes in the supply of securities should affect overnight repo rates on those days. The dependent variable, changes in the amount outstanding under the TSLF, is calculated as the amount awarded in the operation settling that day less the amount maturing that day. Dummy variables are also included for the last and first days of the quarter, on which repo spreads typically widen and narrow, respectively.

The authors find that the TSLF does in fact narrow financing spreads between Treasury collateral and lower quality collateral. Further, the observed narrowing is driven by an increase in Treasury repo rates as opposed to a decrease in rates on lower quality collateral. Financing spreads also widen and narrow on the last and first days of the quarter, as expected.

Additional results show that the effects of the TSLF are driven by "Schedule 2" operations, in which dealers can pledge a wide range of collateral, as opposed to "Schedule 1" operations, in which eligible collateral is limited to Treasury securities, agency debt securities, and agency MBS. The results suggest that that agency debt and agency MBS collateral may be considered substitutes for Treasury collateral to a large degree,

whereas the lower quality collateral that can be pledged in Schedule 2 operations is not.

A final set of results shows that the effects of the TSLF on repo rates and spreads increase with the spread between the fed funds rate and the Treasury general collateral repo rate. That is, changes in the amount of collateral made available to the market have more of an effect when the Treasury repo rate is far below the fed funds rate rather than when it is close to the rate.

Pedersen's discussion highlighted the statistical significance of Schedule 2 collateral and the statistical insignificance of Schedule 1 collateral, which led him to posit that agency and agency MBS behave more like Treasuries than the other lower quality collateral in Schedule 2.

Pedersen maintained that repo spreads are generally mean reverting, and thus controls are necessary for the level of repos and repo spreads. He also questioned whether the quantity of Treasury securities provided by the TSLF is endogenous to the repo rates and spreads: Do high repo spreads lead to a large TSLF amount? Is the large reduction in repo spreads due to general mean reversion or to the TSLF auction? Fleming responded that he and his coauthors consider their results robust.

Lastly, Pedersen addressed what he thought was the big question: Does the TSLF help solve the banks' funding problems and break liquidity spirals? He questioned whether the results of increased repo rates under the TSLF alleviated liquidity problems.

The question-and-answer session centered on Pedersen's "big question" of whether the TSLF effectively achieved its program goals. One participant asked whether the Federal Reserve can effectively work only with primary dealers and banks to reduce haircuts in the repo market, or whether it should consider dealing with investors. Other participants observed that the TSLF is about switching good and bad collateral, as opposed to reducing haircuts, and urged that the intent of the program be kept in mind. Pedersen, by contrast, argued that the program is directly about reducing haircuts, and that the question is whether or not the Federal Reserve has been successful in doing that.

7. Session 6: Empirical Evaluation of Central Bank Liquidity Programs—Part 2

Papers:

"Funding Liquidity Risk: Definition and Measurement"
Mathias Drehmann, Bank for International Settlements
Kleopatra Nikolaou, European Central Bank

Discussant:
Marie Hoerova, European Central Bank

"Provision of Liquidity through the Primary Credit Facility during the Financial Crisis: A Structural Analysis"
Erhan Artuç, Koc University
Selva Demiralp, Koc University

Discussant:
Carolyn Wilkins, Bank of Canada

7.1 Drehmann and Nikolaou

Throughout the current crisis, central banks have introduced facilities aimed at addressing liquidity shortages in financial markets. Despite liquidity's centrality to the crisis policy response, however, a debate continues on the term's precise definition. Drehmann, presenting on behalf of coauthor Nikolaou, set out to define one aspect of liquidity: funding liquidity risk. His presentation focused on providing and testing a definition of funding liquidity risk that could be constructed from public information by central banks.

Drehmann and Nikolaou define funding liquidity as the "ability to satisfy demand for money with immediacy." Consequently, funding liquidity risk reflects the potential inability of a bank to meet money demand over some future period. With this definition in hand, they laid out the theory and construction of a publicly available proxy for funding liquidity risk based on information available from open market operations in the euro area. The measure is based on the theory that, in turbulent times (that is, in the presence of market frictions potentially resulting from asymmetric information, incomplete markets, and issues of market power), a bank with a greater need for liquidity will bid more aggressively for liquidity at the central bank auctions. By looking at the spread between a bank's average bid rate and the policy rate weighted by the volume in a price-discriminating auction, the authors argue that central bankers can easily construct a measure of liquidity risk for each bank or for the system as a whole.

To test their measure of funding liquidity risk, Drehmann and Nikolaou exploit the theoretical relationship between market liquidity and funding liquidity. Some financial theory shows that as funding liquidity risk rises and market frictions become important, downward spirals of funding and market liquidity can occur. Using an average of liquidity proxies for market liquidity in various markets as a proxy for overall market liquidity, Drehmann and Nikolaou demonstrate that their measure of funding liquidity risk does have the negative relationship with market liquidity suggested by theory.

Hoerova's comments on Drehmann and Nikolaou's measure focused on data issues and alternative theoretical considerations. Hoerova pointed out that the measure

proposed by Drehmann and Nikolaou suffers from a number of potential biases, including selection issues and problems related to construction. Selection bias could occur because the choice by banks to participate in the auctions is nonrandom and likely influenced by liquidity conditions. Furthermore, by summing across the value-weighted spread for all banks, the proposed measure could overstate the influence of outliers. The theoretical concerns focused on factors driving bank bidding behavior. A bank could potentially increase its bid rate for a number of reasons unrelated to liquidity risk, such as risk aversion, differences in the personal value of collateral, and the need for "window dressing" around important regulatory dates. Finally, Hoerova suggested that the authors look at alternative measures of market liquidity when documenting their downward liquidity spirals.

7.2 Artuç and Demiralp

Alongside the need for new data to evaluate central bank facilities, another critical issue is the construction of counterfactuals. What would the world have looked like in the absence of certain policies or if the credit crisis had manifested itself in alternative ways? The Federal Reserve made a number of changes to the discount window during the crisis, including reductions in the penalty rate and an increase in borrowing terms. Artuç and Demiralp use model-based counterfactual estimation to examine the impact of these policy changes.

From the data, it is clear that banks responded to the discount window changes by increasing their borrowing substantially, but it is also clear that some cost or stigma was still associated with discount window borrowing because many banks were seeking funds in the interbank market at rates above the discount rate. These trends lead one to wonder how effective the policy changes were in reducing market stress during the credit crisis. Using a structural model of the fed funds market based on each bank's desire to hold certain daily and maintenance-period–wide levels of reserves, Artuç and Demiralp estimate the impact of aggregate shocks to, and changes in, borrowing terms at the discount window. They compare these estimates with simulations in which the cost of borrowing remained unchanged during the crisis period.

Based on the difference between these two models, Artuç and Demiralp find that the Federal Reserve's changes to the discount window were generally, though not universally, effective. Namely, the most effective policy changes were the lengthening of the term of discount window loans and the addition of new eligible collateral. Less effective were the reductions in the spread between the target fed funds rate and the primary credit rate.

In her discussion, Wilkins pointed out three potential shortcomings of this approach to assessing the Federal Reserve policy changes. First, although the structural model helps clarify assumptions and allows for the construction of a counterfactual, some changes remained potentially conflated. In particular, the implicit cost of borrowing from the discount window could come from many sources aside from the stigma cited by Artuç and Demiralp, and certain assumptions such as the static nature of the model might not hold in reality. Second, Wilkins questioned the estimation used to calibrate the model. From the charts presented by Artuç and Demiralp, it appears that some discrepancies exist between the in-sample estimation and the observed data. Also, alternative estimation strategies were not compared with the one used by the authors. Third, Wilkins wondered if other changes were occurring aside from a simple doubling of aggregate shocks that should be included in a model of the crisis period. Most notably, collateral costs were likely changing over the period and other Federal Reserve programs, such as the Term Auction Facility, were introduced to offer additional nonmarket funds to banks. Overall, however, Wilkins emphasized the importance of the policy questions raised by Artuç and Demiralp.

8. Panel Discussion

Chair:
Patricia C. Mosser, Federal Reserve Bank of New York

Panelists:
Louis Crandall, Wrightson ICAP
Andrew W. Lo, Massachusetts Institute of Technology
Paul Mercier, European Central Bank
Lasse H. Pedersen, New York University
W. Alexander Roever, J.P. Morgan Chase

The final event of the conference brought together participants from the private sector, academia, and central banking to discuss the crisis and the policy response. Mosser, moderating the panel, gave participants the freedom to choose topics of interest, but she began the session by posing the overarching question: What are the key policy lessons learned from the crisis so far?

The panelists represented a broad cross section of perspectives on the financial world: Louis Crandall, chief economist at broker Wrightson ICAP; Andrew W. Lo, a professor at MIT's Sloan School of Business; Paul Mercier,

deputy director general of market operations at the European Central Bank; Lasse H. Pedersen, a professor at NYU's Stern School of Business; and W. Alexander Roever, a debt strategist at J.P. Morgan Chase's short-term fixed-income sales and trading desk. Each panelist gave a presentation with his perspective on Mosser's initial question; the panel then opened itself to questions from the audience.

As a fixed-income strategist, Roever focused on the contribution of short-term debt markets to the crisis. He first demonstrated the massive growth in debt markets over the years leading up to the crisis, showing that the U.S. bond and money markets grew 2.5 times faster than GDP from 1998 to 2007. However, Roever said that the figures on money markets do not include debt issued at floating rates indexed to the Libor, which are a close substitute for money market funding, with many of the same characteristics. This development involved not only an increase in leverage on the part of financial firms issuing the debt, but also an increased reliance on a small set of firms, which Roever termed "liquidity investors," encompassing money market funds and other short-term investors with low risk appetites. Within this particular class of investors, Roever showed, assets are heavily concentrated in a very small number of the largest firms. Thus, the risk associated with high levels of leverage was magnified by borrowers' reliance on a narrow group of firms for funding. The crisis thus far has destroyed a large amount of these firms' assets under management, with Roever estimating the overall figure at $2 trillion. This decrease in wealth meant a sudden drop in the amount of money available to fund other financial firms through money markets, asset-backed securities, and other short-term debt, exacerbating the other problems of the crisis. Roever's primary conclusion from this narrative was that the scope of financial regulation has been too narrow, and should be expanded beyond banks to encompass a larger number of participants in the financial system.

Pedersen, whose research focuses on liquidity risk, spoke on the issue of systemic risk, and what central banks and other regulators could do to address it. He began by arguing that the recent crisis, for all its severity, was not a new kind of crisis—that the issues of market liquidity and funding liquidity that came to the fore during the last several months have always been important for financial stability. The key issue, he said, was the systemic component of risk, which he defined as "the joint failure of a significant part of the financial institutions." Among the drivers of this risk were liquidity spirals—the way declines in asset prices can increase the need of financial institutions for liquidity, causing massive simultaneous sales and further drops in asset prices. To highlight the difference between systemic and idiosyncratic risk, Pedersen contrasted the 2008 failure of Lehman Brothers, with all its systemic consequences, with the 1995 failure of the London merchant bank Barings, which was a large institution, but which had relatively minor systemic consequences. The response of regulators, said Pedersen, should be to model and regulate systemic risk explicitly, treating it as a negative externality like pollution. He suggested that regulators run simulations of 1 percent systemic tail risk scenarios, gauging institutions' contributions to losses. Guided by these assessments, regulators should then impose a systemic capital requirement, systemic risk fees after the model of the FDIC, and required loss insurance policies that would be provided by a combination of the government and the private sector. This set of policies, Pedersen argued, would introduce incentives to limit systemic risk and reduce the cost and disruption of bailouts when they become necessary.

Mercier, whose position at the ECB affords him firsthand knowledge of the central bank's transactions with banks, commented primarily on the structure through which the ECB, and central banks in general, inject liquidity into the financial system. Mercier considered a precise concept of liquidity, defined simply as central bank credit. Under "normal" financial conditions, he said, the central bank relies on a small group of large and influential banks to further distribute central bank credit to the rest of the system. In the euro area, this group of banks is much larger than the Federal Reserve's set of primary dealers. With banks hoarding liquidity and the subsequent seizing up of interbank markets, however, Mercier noted that this standard practice started to lose its effectiveness, causing the ECB to lose some control over short-term interest rates. This led the ECB to implement a second regime, in which it made no net change to liquidity over its maintenance periods, but rather frontloaded its injections of liquidity to provide banks and, by extension, their counterparties with more certainty. As the crisis intensified after the collapse of Lehman Brothers, however, the ECB implemented a third regime, marked by fixed-rate tenders of unlimited quantity, which did in fact create a gross increase in liquidity in the system. In net terms, however, there was no increase in liquidity because net demand remained unchanged (except for the increase in banknotes in circulation). While some banks were borrowing more from the Eurosystem, others were increasing their deposits. Both sides of the balance sheet of the Eurosystem increased, leading to a wider exposure toward the banking system. In essence, the Eurosystem became a major intermediary between banks that were reluctant to lend to each other.

While this third regime has apparently been effective in providing financial institutions with needed liquidity, observed Mercier, it has come at the cost of reduced central bank influence over money market lending rates. Mercier pointed to two further lessons from the crisis: first, market psychology

plays a significant role and policymakers need to take it into account, and second, while it is important to consider what central banks' "exit policy" from the crisis should be, it is equally important to consider what a new stable equilibrium would look like—as he put it, "an exit to what?"

Lo based his presentation on the premise that financial crises are unavoidable because of two factors: first, fear and greed are natural parts of human behavior, and second, the economy is and should continue to be based on free markets. As a result of these unavoidable factors, policy efforts should focus on developing early warning systems for impending financial crises and developing measures to address them when they do occur. Much of Lo's recent work has focused on the role of hedge funds in the economy, and he noted that they, along with proprietary trading desks at other financial institutions, generally exhibit early warning signs of impending crises, and that regulators should look to glean information from their activities in the markets. On the question of what new measures regulators should develop to handle financial crises when they do occur, Lo emphasized the necessity of creating a different kind of regulation, rather than just more regulation. After all, he noted, banking and insurance are two of the most highly regulated sectors of the U.S. economy, yet they still played major roles in the recent financial crisis. A major problem with existing regulation, said Lo, is that the main language used for regulation is the language of accounting, which is not well-suited for talking about risk. Accounting, he argued, is fundamentally focused on backward-looking realizations, while financial regulation needs to be focused on risk, which is a fundamentally forward-looking concept.

Crandall, the final presenter, mainly addressed the issue of the currency composition of liquidity. He showed a graph demonstrating the enormous increase in U.S. dollar funds sent from U.S. branches of foreign banks to their home offices over the course of the crisis, as it became more and more difficult for the home offices to obtain U.S. dollar funding in the interbank market. He then showed how this large increase was significantly mitigated by the removal of size limitations on the Federal Reserve's reciprocal currency arrangements with four major foreign central banks, which provide a nonmarket channel through which foreign financial institutions can access U.S. dollar funding. The lesson from this example, according to Crandall, is that the currency composition of a bank's liquidity profile matters. He argued in favor of making the reciprocal currency arrangements permanent, saying that the fixed-rate unlimited-quantity auctions conducted by foreign central banks using the reciprocal currency arrangements had represented a crucial psychological change in financial markets, essentially giving every bank in the world access to a "discount window" denominated in U.S. dollars. Second, Crandall identified one significant limitation facing policymakers: central banks only have the power to incentivize banks, rather than bankers themselves. He pointed out that within banks, profits are socialized (to the bank as a whole), whereas losses are privatized (putting the individual's job at risk). This makes bankers very risk-averse in the sense of being unwilling to learn about new things if they are not directly profitable. Crandall noted that liquidity facilities become more effective as market participants learn more, but that bankers are not paid to learn about these facilities. This poses a special challenge in short-term markets, where less attention may be paid to in-depth research and learning.

A short question-and-answer session concluded the conference. One topic of further discussion was the "exit strategy" that Mercier had brought up in his comments. The participants talked about how long the Federal Reserve and other central banks should wait before revoking current liquidity facilities, many of which are legally allowed to continue only as long as "unusual and exigent circumstances" persist. There was broad agreement that the facilities should remain in place for some time, even after circumstances appear to have stabilized. The panelists noted that many of the facilities are "self-liquidating" because they lend freely but at penalty rates, meaning that market participants will stop turning to them as conditions normalize. Crandall argued specifically that the facilities should remain in place through the period when the Federal Reserve begins to raise rates again. This would do much to instill confidence and remove uncertainty associated with monetary tightening.

The participants also went on to discuss the topic of "greed and fear" that Lo had raised, especially the extent to which such irrational motivations could play a role in creating financial crises. Pedersen suggested that the key shortcoming of the neoclassical model, which posits that irrational agents cannot move markets away from equilibrium as long as there are a small number of rational traders participating, is that agents have funding liquidity constraints. As evidence that funding constraints have recently been binding, he pointed out that covered interest rate parity has been failing for the major currencies because of limited availability of capital and limited willingness to lend, consistent with the idea that liquidity spirals are important drivers of the crisis. Lo cited Keynes' comment that "the market can stay irrational longer than you can stay solvent." More specifically, he pointed out that the neoclassical model requires the posited rational arbitrageurs to have infinite liquidity, which is a particularly unrealistic assumption during financial crises.

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Stephen G. Cecchetti and Piti Disyatat

Central Bank Tools and Liquidity Shortages

1. Introduction

The global financial crisis that began in mid-2007 has renewed concerns about financial instability and focused attention on the fundamental role of central banks in preventing and managing systemic crises. In response to the turmoil, central banks have made extensive use of both new and existing tools for supplying central bank money to financial institutions and markets. Against this backdrop, there has been intense interest in the implications that recent financial developments may have for the fundamental nature of central banks' lender-of-last-resort (LOLR) function and whether the traditional tools that have been at policymakers' disposal remain adequate in the face of modern liquidity crises. This paper addresses these issues, and in doing so provides a view of recent central bank liquidity operations that is tied more closely to their underlying purpose from the LOLR perspective.

We begin in Section 2 by defining three types of liquidity shortages that central banks may need to address in operations aimed at stabilizing the financial system. In taking this approach, we emphasize the fact that the conditions under which central bank liquidity—reserves or central bank money—is made available should, and do, differ depending on the underlying nature of the problem officials are trying to mitigate. This means that there may not be a single set of principles for central banks' LOLR function. Recognizing this goes some way toward reconciling the debate surrounding the appropriate role of LOLR.[1]

After providing our definitions, in Section 3 we proceed with a discussion of the tools that central banks have at their disposal and how they might be tailored to address each type of liquidity shortage. Section 4 offers a brief description of how recent actions by major central banks can be interpreted from this perspective; Section 5 concludes. We note at the outset that our focus is on central bank liquidity operations and not on policymakers' interest rate responses.

2. Liquidity Shortages and the Lender of Last Resort

Apart from the conduct of monetary policy, a vital responsibility of central banks in most countries is to perform the role of LOLR. At its core, the objective of the LOLR is to prevent, or at least mitigate, financial instability through the provision of liquidity support either to individual financial institutions or to financial markets. The underlying premise is that shortages of liquidity, by which we mean the inability of an institution to acquire cash or means of payment at low cost, can lead to otherwise preventable failures of institutions that then

[1] We do not enter the debate over whether the LOLR takes the place of a deposit insurance system. Recent events, especially the retail bank runs that accompanied the nationalization of Northern Rock in the United Kingdom, would appear to have settled the matter in favor of the importance of a rule-based deposit insurance system.

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result in spillover and contagion effects that may ultimately engulf the financial system more broadly with significant implications on the real economy.[2] By signaling its willingness and ability to act decisively, the central bank demonstrates its intention to restore confidence in the system by avoiding "fire sales" of assets and supporting market functioning.

The "classical" doctrine of the LOLR as attributed to Thornton (1802) and Bagehot (1873) is commonly interpreted to imply that such lending should be extended freely without limit, but only to solvent institutions at penalty rates and against good collateral (for example, see Rochet and Vives [2004]). This set of principles has been subject to substantial debate for much of the past thirty years, with many issues yet to be resolved.[3]

At their most basic level, the underlying principles of Bagehot's original dictum have been subject to a variety of interpretations. Goodhart (1999), for example, emphasizes that Bagehot's criteria for lending were not conditioned on the individual borrower but on the availability of good collateral. As such, the distinction between illiquidity and insolvency would not be an important issue. Similarly, while the imposition of a penalty rate has traditionally been judged relative to the prevailing market rate, it can be argued that Bagehot advocated only that lending take place at a rate higher than the precrisis level. Given that the LOLR strives to achieve the good—panic-free—equilibrium, a case can be made that the penalty ought to be relative to the interest rate during normal times rather than the higher rate that obtains in the market during a panic (Goodhart 1999). Indeed, in practice, LOLR lending has frequently taken place at prevailing market rates (Giannini 1999).

At a more practical level, the distinction between illiquidity and insolvency has been largely dismissed on the grounds that banks generally face liquidity problems when solvency is in question (Goodhart and Schoenmaker 1995). Indeed, an individual bank will seek assistance from the monetary authorities only when it cannot meet its liquidity needs in financial markets. Since the wholesale interbank money market is the first stop for most banks, this almost certainly means that there are significant doubts about the institution's ultimate solvency. The proposition that central banks only lend against good collateral is also undermined by the fact that a bank that is unable to raise funds in the market must, almost by definition, lack access to good security for collateralized loans. As such, emergency lending assistance from the central bank will likely be against collateral of questionable quality. In addition, the imposition of a penalty rate has been criticized on the grounds that such a policy could compound the problem if it imposes a substantial burden on the troubled institution.

At the same time, another facet of the debate has focused on the appropriate implementation of LOLR support. Some argue that in an advanced financial system, LOLR should be exclusively through open market operations. As long as systemwide changes in demand for reserves are met through such operations, the market can direct reserves to those most in need, thereby avoiding the mispricing that administrative mechanisms might create (Schwartz 1992; Kaufman 1991; Goodfriend and King 1988). Such an approach was clearly successful, for example, in the case of operations associated with the spikes in liquidity demand during the Y2K episode and in the aftermath of the stock market crash of October 1987. However, others argue that LOLR may require direct lending, not open market operations, as the market may fail to deliver liquidity to distressed banks whose failure threatens the financial system (Rochet and Vives 2004; Freixas et al. 2000; Freixas, Parigi, and Rochet 2000; Goodhart 1999).

2.1 Three Kinds of Liquidity Shortages

Rather than getting mired in the theoretical debate on the design and role of the LOLR, we take a more pragmatic approach and outline the broad conditions under which central banks' provision of liquidity is undertaken in practice. From this we derive some general principles that apply depending on the specific situation. Indeed, once it is recognized that the nature of the LOLR differs across circumstances, many of the issues at the center of the theoretical debate fade.

It is useful at the outset to distinguish between three types of liquidity: central bank liquidity, market liquidity, and funding liquidity. *Central bank liquidity* is the term we use to describe deposits of financial institutions at the central bank; it is synonymous with reserves, or settlement balances. These reserve balances are held by financial institutions to meet reserve requirements, if any, and to achieve final settlement of all financial transactions in the payments system. Individual institutions can borrow and lend these funds in the interbank market, but, for the system as a whole, the only source of these funds is the central bank itself.

Market liquidity refers to the ability to buy and sell assets in reasonably large quantities without significantly affecting price. This use of the term "liquidity" is closest to the common, textbook definition: the ease with which an asset can be converted into means of payment (that is, money or cash).

Finally, there is *funding liquidity*. This term describes the ability of an individual or institution to raise cash, or its

[2] This definition of LOLR is quite broad and can, in principle, encompass any injection of central bank reserves, including routine ones. That said, we focus primarily on extraordinary interventions driven by unanticipated events.

[3] See Davis (2008) and Rochet (2008) for detailed expositions of the various views.

equivalent, again in reasonably large quantities, either via asset sales or by borrowing. As such, market and funding liquidity are closely linked (see Brunnermeier and Pedersen [2007]).

With this distinction in mind, our discussion of central banks' liquidity operations and their appropriate structure with respect to the fulfillment of the LOLR function is best premised on the clear separation of three kinds of liquidity shortages: a shortage of central bank liquidity, an acute shortage of funding liquidity at specific institutions, and a systemic shortage of funding and market liquidity. We now proceed to describe each of these in turn.

Shortage of Central Bank Liquidity

The first kind of liquidity shortage is perhaps the most benign and occurs when institutions find themselves short of the reserve balances that they wish to hold, either because of inadequacies in the aggregate supply of reserves or problems associated with their distribution within the system. In this situation, financial institutions risk being unable to fulfill their immediate payment obligations, creating the potential for "gridlock" in the payments system. Typically, the tensions manifest themselves in a spike in the overnight interest rate but may sometimes also be transmitted to other segments of the money market as well. For the most part, these problems occur in the absence of any concern over the solvency of specific institutions.

When central bank liquidity shortages occur as a result of problems associated with the distribution of reserves, the underlying cause is typically technical in nature, having to do with either technological glitches or mismanagement of liquidity positions. The computer malfunction at the Bank of New York on November 20, 1985, which resulted in a large shortage of cash despite the bank's patent solvency, and the September 2001 crisis are examples of such situations. The immediate problem confronting central banks in each case was the dislocation of reserves, reflecting a breakdown in payments systems and the coexistence of institutions unable to lend excess funds to institutions that desperately needed them.

A shortage of central bank liquidity can also arise from an inadequate supply of reserves to the system as a whole.[4] This may reflect an error in the central bank's forecast of autonomous factors affecting liquidity conditions (for example, as a result of unexpected changes in the Treasury's balances with the central bank) or a sudden, unanticipated shift in demand, or both. At the beginning of August 2007, for example, a sharp rise in uncertainty over future funding availability led to an abrupt increase in demand for reserves in the system as a whole. This put considerable upward pressure on overnight rates, and many central banks initially found it harder to achieve their policy targets. The natural policy response was an immediate increase in the supply of reserves in an effort to meet what officials hoped would be a brief shortage of central bank liquidity.

[4] Since it assumes that the interbank market is still functioning normally, this situation is close in nature to the problem envisaged by Goodfriend and King (1988).

Acute Shortage of Funding Liquidity at Specific Institutions

The second kind of liquidity shortage occurs when a particular institution experiences an acute shortage of funding liquidity associated with solvency concerns as the willingness of counterparties to trade with the institution dissipates. This situation can arise as the result of a flawed business strategy—which becomes evident often only ex post—that has left the institution exposed to persistent cash drains. Reflecting substantial perceived insolvency, the shortage of liquidity is prolonged and the form of assistance needed is essentially bridge financing that allows time for fundamental restructuring.

The primary threat posed by an institution-specific acute liquidity shortage, and hence the main justification for any official assistance, is that failure may result in contagion and spillover effects that could put the entire financial system at risk. The key criterion in the consideration of liquidity support is then whether the institution in question is systemically important or not. The distinction between illiquidity and insolvency is not really relevant. Prominent examples of situations in which an acute shortage of funding liquidity at certain institutions necessitated LOLR support include Continental Illinois in 1984 and the provision of liquidity support to various bank and nonbank financial institutions in the current crisis.

Systemic Shortage of Funding and Market Liquidity

The final form of liquidity shortage—a systemic shortage of both funding and market liquidity—is potentially the most destructive. It involves tensions emanating from an evaporation of confidence and from coordination failures among market participants that lead to a breakdown of key financial markets. Markets, just as intermediaries, may be subject to "runs" that are driven by fundamentally similar forces. As we saw in the immediate aftermath of the September 2008 bankruptcy of Lehman Brothers, the result is a sudden

and prolonged evaporation of both market and funding liquidity, with serious consequences for the stability of both the financial system and the real economy.

Such crises are generally associated with a sharp rise in market participants' uncertainty about asset values as well as about the financial strength of potential counterparties. Because financial markets need participants to function, a sharp rise in uncertainty that causes many players to disengage results in illiquid markets (see Caballero and Krishnamurthy [2008]). As a direct consequence, assets that were thought to be easily convertible into cash are not, which creates funding liquidity problems for individuals and institutions. This, in turn, heightens the credit risk of potential counterparties. The dynamics of these systemic crises are then driven by a mutually reinforcing feedback process involving market liquidity, funding liquidity, and counterparty credit risk.[5] The 1987 stock market crash is an example of such a situation, and systemic liquidity shortages have been a prominent element of the current crisis from the very beginning.[6]

3. Central Bank Tools and Liquidity Shortages

The three types of liquidity shortages—central bank, acute institution-specific funding, and systemic funding and market—do not always occur in isolation. Important interdependencies exist, and the occurrence of one can lead to another with dynamics that often reinforce one another. For example, acute concerns about the viability of a particular institution can rapidly spread to a loss of confidence in other institutions, resulting in systemic disruptions in the interbank market that, in turn, hamper the distribution of reserves among participants, leading to problems in the payments system. Indeed, the current crisis that began in mid-2007 has involved all forms of liquidity shortages.[7]

In their capacity as LOLR, central banks essentially have three tools with which they can influence the availability of liquidity in the financial system. The first is lending or borrowing in the open market. These operations include the repos and reverse-repos that are the bread and butter of liquidity management during normal times. They are not targeted at specific institutions—though they may be undertaken bilaterally—but are designed to address systemwide liquidity pressures. The operations are typically collateralized and conducted at the discretion of the central bank. The basic function is to regulate the level of aggregate reserves to ensure smooth functioning of the payments system and facilitate the attainment of the relevant policy interest rate target. That said, these operations can be utilized and structured to address a broader set of problems as well. For example, through these operations, central banks may lend not only reserves but also highly liquid securities such as government bonds.

The second tool is the outright purchase or sale of assets in the open market. These operations affect the aggregate supply of central bank money (reserves) on a permanent basis and are typically conducted in sovereign bonds denominated in either domestic or foreign currencies. Prior to the current episode, similar interventions in other asset markets were rare. The purchases of equities by the Hong Kong Monetary Authority during the 1997 Asian financial crisis and by the Bank of Japan in 2002 were notable exceptions. The application of outright transactions aimed at affecting market prices is quite controversial and is usually justified in terms of correcting a fundamental misalignment in asset prices or the provision of two-way liquidity.

Finally, central banks can conduct transactions directed at specific institutions instead of markets as a whole. Unlike open market operations, these transactions can take place at the discretion of either the central bank or the financial institution itself, involve the channeling of liquidity directly to or from particular institutions, and can be either collateralized or uncollateralized. Examples of such operations include standing facilities and traditional emergency lending assistance.

The specific institutional setup of each of these three tools varies a great deal across countries—including differences in maturity, frequency, counterparty arrangements, and eligible collateral. These variations can have significant implications for how financial institutions manage their own liquidity positions as well as for the liquidity characteristics of various assets themselves.[8] Moreover, the specific setup of each of these tools crucially determines their function during a liquidity crisis. Depending on their structure, each can in principle contribute to the alleviation of all three types of liquidity shortages discussed earlier. The key features that characterize their application to various types of crises are set out below and are summarized in the table. Unsurprisingly, the choice of tool to be employed will depend on the type of liquidity shortage that has arisen. Critically, this means that unlike the framework

[5] Brunnermeier and Pedersen (2007) provide a formal representation of this mutually reinforcing process. Freixas, Parigi, and Rochet (2000) and Flannery (1996) develop models that illustrate how coordination failures can lead to a systemic seizing up of the interbank market. See also Borio (2004).

[6] A detailed exposition of the 1987 crisis can be found in Carlson (2007).

[7] A broad analysis of the current crisis is provided by Borio (2008), Bank for International Settlements (2008a, 2008b), Calomiris (2008), Cecchetti (2008), and Gorton (2008).

[8] Markets Committee (2008) contains detailed descriptions of the specific practices for a large cross-section of countries.

Principles of Lender-of-Last-Resort Support

Nature of Liquidity Support	Type of Liquidity Shortage		
	Shortage of Central Bank Liquidity	Chronic Shortage of Funding Liquidity at Specific Institutions	Systemic Shortage of Funding and Market Liquidity
Distinction between illiquidity and solvency	Yes	No	No
Directed lending or open market	Either	Directed	Both
Lending or outright	Lending	Lending	Both
Ambiguity of access	No	Yes	No
Penalty relative to market rate	No, if aggregate shortage Yes, if institution-specific	No	No
Quality of collateral/degree of central bank risk exposure	High/negligible	Low/high	Low-high/low-high
Term of support	Very short (overnight)	Long	Short to medium
Public announcement of support	No	Depends	Yes
Separation from monetary policy	Yes	Yes	No
Coordination with fiscal authority	No	Yes	Yes

set out by Bagehot in the nineteenth century, there is no unique set of principles that governs how the LOLR should respond.

Before describing how central banks use their tools to respond to each of the aforementioned liquidity shortages, it is useful to note some key implications for their balance sheets. The fulfillment of the LOLR function typically involves changing the composition of assets held by the central bank, the overall size of its balance sheet, or both. In doing so, central banks will normally offset any impact on reserve balances outstanding in order to maintain the policy interest rate near its target. The main exceptions to this are: 1) if there is an aggregate shortage of central bank liquidity; 2) if the policy rate is zero; or 3) if reserves are remunerated at the policy rate. Whether the overall size of the balance sheet expands or not then depends on the choice of offsetting operations. If the latter is achieved by allowing one asset to substitute for another, then balance-sheet size is unchanged. However, if the offset is achieved through the issuance of various forms of central bank liability, such as an increase in the size of the government's deposit balance or the sale of central bank bills, balance-sheet size increases. Typically, the latter becomes necessary as the scale of liquidity support rises beyond a certain point.

3.1 Shortage of Central Bank Liquidity

When central banks are faced with a shortage of reserves in the banking system as a whole, the primary aim of their intervention is to maintain the smooth functioning of the payments system and keep interest rates near their targets. If the problem is largely one of insufficient aggregate supply, all three forms of central bank intervention can be employed to address the situation. Generally, however, the preferred option is to accommodate the extra demand for reserves by lending in the open market and relying on the market to distribute reserves to those most in need. The provision of additional reserves would typically not be at a penalty rate since the maintenance of the appropriate aggregate supply of reserves is an important remit of central banks. Moreover, the underlying cause cannot generally be attributed to mismanagement on the part of banks. The sharp pickup in demand for liquidity buffers that began in August 2007, for example, reflected a general rise in uncertainty regarding future funding needs that was largely unforeseen.

If the shortage of reserves is caused by problems related to their distribution within the banking system—a situation associated with frictional payment shocks that leave some institutions suddenly and unexpectedly short of funds—the LOLR function can be implemented through directed liquidity support. Standing facilities, where banks can either deposit excess balances or borrow additional balances directly from the central bank at prespecified rates at the end of the day, are designed to handle these situations. Since the nature of the problem envisaged is largely transitory, this type of liquidity support is designed to be extended for a very short term, usually overnight. Moreover, to maintain the incentive for financial institutions to transact in markets, central banks tend to make access to standing facilities at penalty rates of interest. Finally, standing facilities can exert a stabilizing influence on markets without any funds actually being lent, since their mere presence can act to assure banks of orderly access to overnight funds. This effect is ensured by making access unambiguous.

Regardless of whether the central bank liquidity shortage is systemwide and institution-specific, the operations conducted to address it are designed explicitly to minimize the impact on market prices of all securities other than the overnight interest rate. As such, their implementation has no bearing on, nor is it in conflict with, the official stance of policy. Furthermore, since the terms are very short and all loans are fully collateralized, the central bank faces virtually no credit risk. The principles behind standing facility lending are in fact very much in line with conventional interpretations of Bagehot's instructions to lend freely to solvent institutions, against good collateral, at a penalty rate. As emphasized by Paul Tucker, much of the central bank lending that was discretionary in Bagehot's day has, in effect, become "hard coded" into the operating framework (Tucker 2004).

While these operations work well most of the time, the current crisis has highlighted some potential constraints that may arise in the use of both open market operations and traditional standing facilities. For one, financial institutions may not have sufficient access to the types of assets that the central bank regards as being of acceptable quality to serve as collateral. In addition, the institutions most in need of central bank liquidity may not have direct access to the central bank itself. As recent experience has shown, development of more global capital markets has made it more likely that disturbances will originate in markets and involve counterparties that are several steps removed from the central bank's sphere of direct operation. Finally, when financial institutions lose confidence in nearly all potential counterparties, bringing their soundness into question, access to standing facilities can become stigmatized, impairing the effectiveness of these facilities as a liquidity backstop. This was particularly evident in the United States during 2007 and 2008, when market rates at times rose well above the interest rates on the facilities (see Committee on the Global Financial System [2008]). As we discuss in more detail in Section 4, central banks have addressed these problems by widening the pool of eligible assets, broadening the range of institutions with which they are willing to transact directly, and assuring market participants that borrowing from standing facilities should not be regarded as a sign of weakness.

3.2 Acute Shortage of Funding Liquidity at Specific Institutions

When the official sector confronts an institution facing an acute shortage of funding liquidity, the justification for intervention must be that failure threatens the stability of the entire financial system. In such a circumstance, the solvency of the institution will be of secondary importance. Instead, central bankers are faced with a decision whether to exercise discretionary authority to provide emergency lending assistance to a particular institution. Clearly, this situation is distinct from the one just described, in which an institution finds itself short of funds at the end of the day. Rather, the problem is one of large-scale and potentially prolonged shortages of funding liquidity against which the use of standing facilities is inadequate or inappropriate. Furthermore, given the institution-specific nature of the intervention, emergency lending assistance can be clearly separated from the monetary policy stance.

Any liquidity support extended in this situation will likely expose the central bank to credit risk, since an institution in need of a loan of last resort will typically have exhausted its stock of both marketable assets and acceptable collateral. So the assets pledged to the central bank are likely to be some part of the borrowing bank's loan book, or illiquid securities, or some physical asset whose value is uncertain. To the extent that a loan extended under this circumstance is, in the end, simply bridge financing while a takeover or major restructuring of the recipient institution is organized, it will generally be accompanied by a plan for private sector (Bear Stearns) or government (Northern Rock) support or recapitalization. This acts, at least in principle, to limit the central bank's exposure to substantial losses.

A key factor determining the scope and scale of emergency lending to an institution facing an acute shortage of funding liquidity is the central bank's ability to absorb losses. In this context, the current crisis highlights serious potential resource limitations. As financial institutions have become increasingly globalized, the scale of any potential support required has grown tremendously, requiring the joint participation of fiscal authorities. Moreover, in cases such as Iceland in 2008, it can even stretch beyond the limits of the entire official sector.

Because of the moral hazard implications, officials are tremendously hesitant to grant such loans. When they do, they not only charge high rates of interest to mitigate taxpayer exposure but have the ability to write down shareholder equity as well as replace management. Insofar as the institution is unable to obtain funding on its own in the market, however, the provision of liquidity support cannot necessarily be deemed punitive relative to the market rate.[9] As a further counterbalance to moral hazard, the provision of support to acutely illiquid institutions is on a discretionary basis so that the market does not take it for granted. Such "constructive ambiguity" does not necessarily mean, however, that the

[9] The imposition of a penalty rate is determined largely by the degree of moral hazard that is associated with the provision of liquidity support. We discuss this further in Section 3.4.

general set of principles that would justify emergency lending assistance should not be made explicit. Taylor (2009), for example, argues that uncertainty about what the government would do to aid financial institutions, and under what circumstances, was a key factor in the deterioration that marked the current crisis.

Once an emergency loan is granted, communication can be critical in determining the chances of success. On the one hand, the announcement of assistance may work to assure the public that the financial system is sound, thereby boosting confidence among market participants. On the other hand, news of liquidity support may confirm public fears about potential failures, and the institution receiving support may suffer a further loss of reputation. In the United Kingdom in 2007, news of LOLR support to Northern Rock precipitated a retail deposit run, which was stopped only by announcement of a government guarantee. In the wake of this incident, banks understandably became unwilling to access central bank lending facilities even for more benign liquidity needs, for fear of reputational consequences. The result was a further tightening up of the money market, which worsened an already bad situation.

While stigma is surely not a relevant issue for an ostensibly failing institution seeking emergency lending assistance, the central bank's decision to grant a request may worsen the stigma associated with all forms of direct lending, complicating liquidity management. Confidentiality may help to prevent knowledge of LOLR support from giving rise to panic, but maintaining it is difficult in practice since banks usually know the approximate condition of their competitors, and the scale of such operations would typically necessitate public oversight.

3.3 Systemic Shortage of Funding and Market Liquidity

The limits of the central bank's LOLR function are most severely tested in a systemic liquidity crisis, not least because such situations are likely to be accompanied by the other two types of liquidity shortages as well. In this circumstance, the underlying aim of official intervention is to shore up confidence in the financial system as a whole, restoring market functioning through the reestablishment of both funding and market liquidity. This will help forestall asset fire sales, facilitate the orderly reduction in borrowing, support the process of price discovery in markets, and restore credit flows. Succeeding will almost surely require utilization of all of the forms of central bank liquidity intervention described earlier and may involve substantial modifications in standard practices and procedures. In addition, as is fairly clear, the central bank could well become exposed to considerable market and credit risk.

In a systemic liquidity crisis, the key challenge facing central banks is to find ways to contain flight-to-quality and re-engage the private sector in the intermediation process. Such re-engagement will occur only as agents' uncertainty over outcomes is reduced. To this end, the central bank will have to perform an intermediating role, and its actions may be designed to supplement the role of banks or even bypass banks altogether. Indeed, whereas the primary function of the LOLR in traditional discussions is to liquefy the balance sheet of banks, the current crisis has highlighted that when faced with a systemic crisis in a market-based financial system, the scope of LOLR support is likely to be much broader and involve interventions more akin to liquefying the limit order book of a particular market.

Typically, this will require a broadening of the central bank's provision of liquidity both in terms of accessibility and structure. Tensions in the term funding market, for example, can be alleviated by the central bank both directly (through greater provision of term funding that offsets some of the shortfall in market supply) and indirectly (through the assurance of access to liquidity directly from the central bank). To the extent that the latter helps to ease intermediaries' concerns about rollover risk, they may become more willing to extend term loans. At the same time, the set of institutions with which the central bank transacts may need to be expanded to ensure that the interventions reach those most in need.

A basic thrust of liquidity operations during a systemic crisis is to accommodate the increase in demand for assets of unquestionable quality while at the same time financing those institutions that find it hard to borrow in the market. This involves shifting the asset composition of central banks' balance sheets away from highly liquid assets (primarily government securities) toward less liquid ones (typically private sector debt). In some instances, it may be necessary to sidestep the banking system and provide funding directly to borrowers and investors in key credit markets. This may be accomplished through outright purchases of, or lending against, specific classes of debt linked to particular market segments (for example, mortgages or corporate bonds). By reassuring investors that a committed buyer is in the market, such interventions may reduce the liquidity premium on various asset classes and boost the flow of credit. More generally, market prices may be influenced through the portfolio balance effect, whereby the change in the relative supplies of imperfectly substitutable private and public securities will lower the premium that the private sector demands for holding risky private securities at the margin. In addition, by making an asset eligible for central bank

operations, the liquidity premium that might otherwise be needed to induce investors to hold that asset will be reduced.

Because the purpose of these policies is to affect market pricing of specific assets independently of the overnight rate, it will be difficult to distinguish them from the stance of monetary policy per se. They also represent a departure from the conventional view that monetary policy should refrain from directly influencing relative prices by not targeting specific asset prices. Indeed, whether yield spreads are too wide or whether specific bonds are rationally priced given the amount of risk inherent in the prevailing economic outlook is largely a subjective assessment. Justification for such policy actions, then, rests on the same logic that has been used to motivate foreign exchange interventions—the enhancement of two-way liquidity or the attempt to move a misaligned asset price.

Ultimately, though, a systemic crisis is less amenable to central bank intervention. Central bank tools are much more limited in this context, since the fundamental problem is more greatly removed from monetary policymakers' sphere of influence. The bulk of market and funding liquidity is generated through transactions among private entities and, as such, is created endogenously in the financial system. In an environment where there is pervasive uncertainty about banks' balance sheets, both because asset valuations of various types become problematic and because of incomplete knowledge about what assets each bank holds, a central bank's liquidity operations can ease these problems only indirectly, alleviating the symptoms rather than the cause. Central banks can provide liquidity by transacting with market participants, but they are not able to directly ensure that private agents will transact with each other.

In the end, whether central bank actions are effective in attenuating the impact of a systemic crisis and restoring the functioning of markets depends on the extent to which they have a catalytic effect on mutually voluntary private sector transactions. A key aim would be to generate a virtuous cycle that relies primarily on the private sector to re-establish liquidity in interconnected markets. In this respect, announcements of intended actions can be sufficient if they are credible. During the 1987 crisis, for example, the Federal Reserve not only encouraged banks and securities firms to make credit available to brokers and dealers but also issued very public statements affirming its commitment to providing liquidity. Carlson (2007) argues that the latter was critical to stabilizing the situation.

By extension, ambiguity of access to central bank liquidity facilities is likely to be counterproductive during a systemic crisis. On the contrary, uniform access for all financial institutions, irrespective of their condition and systemic importance, is more likely to alleviate heightened counterparty fears. Standing facilities and loan guarantees are examples of intervention that can have this kind of catalytic effect without the liquidity actually being drawn upon. For example, several of the new facilities introduced by the Federal Reserve in the current crisis are available at the discretion of market participants (the PDCF, AMLF, CPFF, MMIFF, and TALF), while others appear to have been structured to encourage market intermediation of credit.[10]

Importantly, the implementation of such measures involves an intricate balancing act. To the extent that an expanded intermediation role discourages financial institutions from dealing with one another, the central bank's response may create countervailing forces between catalyzing market activity on the one hand and substituting for it on the other. The onus then falls on the design of an appropriate pricing structure and well-defined exit strategies, both of which can be difficult to achieve in practice.

Finally, in a situation of generalized market failure, it makes less sense for liquidity support to be provided at a penalty rate relative to prevailing market rates since no particular institution is benefiting relative to others. In fact, liquidity support will often, and probably should, be provided at a subsidized rate when it involves an illiquid asset in which a market price cannot be found. That said, liquidity facilities may be designed in ways so that accessing them is not punitive when markets are dysfunctional and is punitive when normal activity returns.[11] Doing so would also naturally lead to an automatic run-off of liquidity support as markets stabilize.

3.4 Lender of Last Resort and Moral Hazard

The creation of moral hazard is a long-standing concern associated with LOLR operations. Goodhart (2007), for example, argues that generous provision of liquidity by central banks, in normal times and in times of crisis, has made banks careless in managing their liquidity risks. With this in mind, it is useful to assess the nature of moral hazard in light of the different types of liquidity shortages we set out here. As will become apparent, we view the moral hazard created by the LOLR as either relatively unimportant in practice or an issue

[10] The TALF (Term Asset-Backed Securities Loan Facility), for example, provides term credit against newly issued asset-backed securities rather than outright purchases, which creates an incentive for participants to establish sound collateral for the securities since they are likely to be kept on their books. The PDCF is the Primary Dealer Credit Facility; the AMLF is the Asset-Backed Commercial Paper Money Market Fund Liquidity Facility; the CPFF is the Commercial Paper Funding Facility; the MMIFF is the Money Market Investor Funding Facility.

[11] Many of the Federal Reserve's new facilities in the current crisis are designed this way. The CPFF, for example, charges a fixed spread over the three-month market rate that should become unattractive in normal times.

that is best addressed by other facets of policy not directly associated with the provision of liquidity support itself.

With respect to shortages of central bank liquidity, the potential for moral hazard arises if the provision of liquidity support reduces the incentive for financial institutions to devote resources to enhancing the efficiency and effectiveness of their daily liquidity management operations. Moreover, excessive reliance on the central bank for daily liquidity management would substantially undermine private interbank market activity. Central banks have generally responded to these issues successfully through the establishment of a pricing structure that preserves the incentive for market participants to trade with one another before going to the central bank's standing facility.

Looking at the case of an acute shortage of funding liquidity at specific institutions, we note that the underlying moral hazard concern is that the extension of liquidity assistance could establish precedents that lead to lax risk management and make financial institutions generally more vulnerable to shocks. Attempts to address these concerns have centered on both the prevention of potential problems through regulatory frameworks such as prompt corrective action and the imposition of highly punitive financial and nonfinancial penalties on management and shareholders in the process of crisis resolution. The latter makes it unlikely that expectations of liquidity support will directly contribute to the taking on of excessively risky activities. Nevertheless, to the extent that creditors are protected from losses, the exercise of market discipline is weakened. This in and of itself may facilitate (rather than cause) the pursuit of excessively aggressive business strategies.

Finally, in situations of systemic crisis, the underlying coordination failures that trigger the crisis cannot be easily attributed to anticipation by private agents of government support measures in the event of a financial meltdown, so it is difficult to see how it could have been the outcome of moral hazard. Indeed, if one views the evaporation of liquidity in key financial markets as a form of market failure—associated with the inability of markets to cope with aggregate, as opposed to idiosyncratic, liquidity shocks—a case can be made that the provision of liquidity support in systemic crises serves to enhance social welfare (see, for example, Kearns and Lowe [2008]).

At the same time, expectations of generalized liquidity provision by the central bank in systemic crises may lead institutions to neglect the task of building buffers that can be run down during such events. In this way, the inherent financial fragility that potentially contributes to making systemic crises more likely may be partly attributable to complacencies in risk management associated with anticipation of central bank intervention. This does not, however, constitute grounds for the central bank to refrain from providing support should a systemic crisis occur, nor does it suggest that provision at that time should be on highly punitive terms. Economically and politically, authorities have little choice but to act in the midst of a crisis, and any ex ante stance precluding provision of such support cannot be made credible. Thus, even if the existence of the central bank's liquidity facilities creates moral hazard, efforts to mitigate it are more productively channeled elsewhere. Insofar as crises are associated with complacency in risk management, mistaken assumptions about asset price trajectories that become evident only ex post, skewed compensation arrangements, limited liability, and overall financial conditions that encourage risk-taking, the burden of their prevention falls more naturally on the appropriate management of macroeconomic policies and regulatory structures than on the specifics of the framework for emergency liquidity provision.

4. Liquidity Operations during the Current Crisis: The LOLR Perspective

In the face of the widespread financial market dislocations that began in August 2007, central banks have expanded liquidity operations, actively deploying their balance sheets to address all three types of liquidity shortages. While the inherent cause of the current crisis may be rooted in coordination failures and informational asymmetries—and so is not new—the scale and scope of the problem have necessitated measures in some countries that are clearly unprecedented. In particular, because institutions have come to depend on market-based sources of liabilities, replacing lost funding liquidity now requires interventions on a scale that is large relative to the size of the central bank's balance sheet in normal times. This section outlines the general thrust of central banks' actions from the perspective of their LOLR function.[12]

Each of the measures central banks have undertaken since the fall of 2007 can be seen as addressing directly or indirectly at least one of the three types of liquidity shortages. With respect to addressing shortages of central bank liquidity, the focus has been on accommodating the greater instability in the demand for reserves and alleviating distributional problems. These have been addressed by varying the size and frequency of operations—conducting them outside their regular schedule and in larger than usual amounts—broadening the number

[12] For further details on central bank actions, see Bank for International Settlements (2008b) and Committee on the Global Financial System (2008).

and type of counterparties, and enlarging the scope of eligible collateral. A key objective of these interventions has been to contain deviations of market rates from the official policy stance (Chart 1).

For acute shortages of funding liquidity at specific institutions, central banks have extended emergency lending assistance to various financial institutions. This involved, for example, the extension of credit to Northern Rock by the Bank of England; the Federal Reserve's support for Bear Stearns, AIG, and Citigroup; and the Swiss National Bank's financing of the transfer of distressed assets out of UBS. These actions were undertaken jointly with the fiscal authority and generally structured to minimize the financial risk to the central bank.

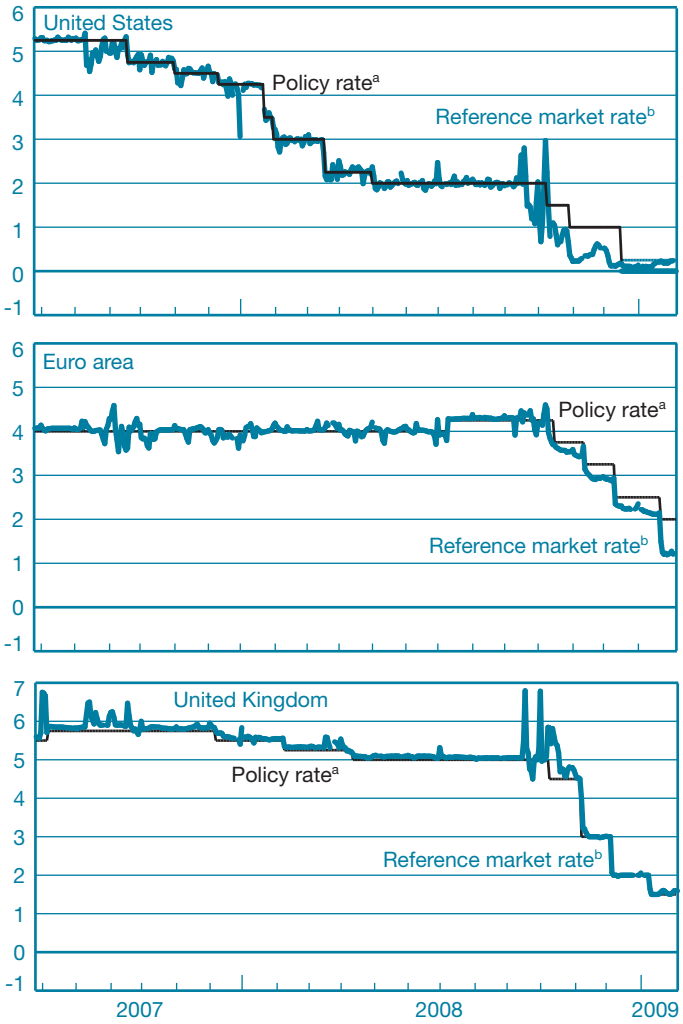
Finally, there have been four broad components to efforts aimed at alleviating systemic shortages of funding and market liquidity. First, central banks have sought to ensure the availability of backstop liquidity to key financial institutions as reflected, for example, in the creation of the Federal Reserve's PDCF, which established overnight funding for primary dealers. Second, there has been an effort to provide greater assurance of the availability of term funding through the lengthening of the maturity on refinancing operations as well as the establishment of inter–central-bank swap lines to ensure the availability of (primarily) dollar funding in offshore markets. Third, policymakers have worked to provide high-quality securities—usually sovereign ones—in exchange for lower quality, less liquid securities in order to encourage trading in the latter. The Federal Reserve and the Bank of England, for example, established facilities to lend government securities in exchange for less liquid market securities. Fourth, there have been initiatives aimed at ensuring the availability of credit to non-banks in cases where particular financial markets had become inoperative. The Federal Reserve's extension of credit through the CPFF and the TALF, direct purchases of mortgage-backed securities issued by key government agencies, and the Bank of Japan's outright purchases of commercial paper are examples of such an approach.[13]

Over the past sixteen months, central bank actions have covered this broad spectrum through two main phases. During the first phase (through mid-September 2008), central bank efforts were undertaken by varying the asset composition of their balance sheets while keeping the overall size largely unchanged. As the crisis intensified following the collapse of Lehman Brothers, central bank operations entered a second phase that involved a rapid expansion of the size of their balance sheets. In particular, as central banks increased the size and scope of their efforts to support market functioning and undertook larger emergency lending assistance, offsetting operations on the asset side of their balance sheets became

CHART 1

Policy Rates and Reference Market Rates

Percent



Sources: Bloomberg; national data.

[a] For the United States, federal funds target rate; for the euro area, minimum bid rate; for the United Kingdom, official bank rate.

[b] For the United States, effective federal funds rate; for the euro area, Eonia; for the United Kingdom, overnight Libor rate.

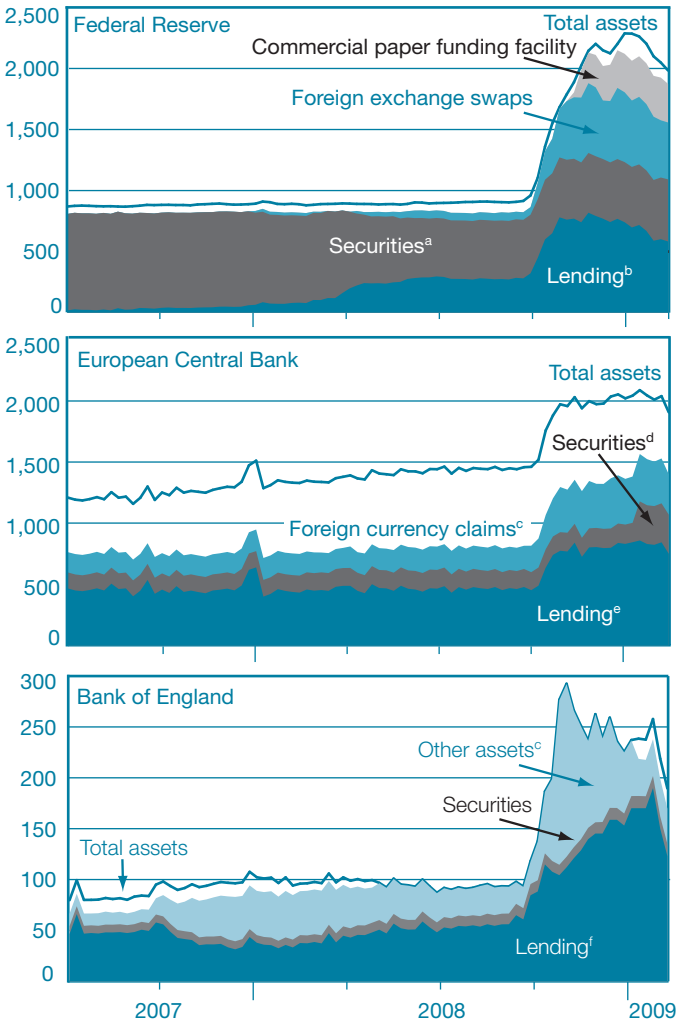
[13] It is useful to emphasize that these somewhat unconventional liquidity operations can be applied regardless of the level of the policy rate itself. Central bank balance sheets can expand aggressively even when interest rates are positive, contrary to the widely held view that such expansion can take place only at the cost of pushing rates to zero. The latter view is often based on Japan's "quantitative easing" experience; however, the ability to expand the balance sheet without compromising targets for interest rates is constrained only by central banks' capacity to offset the impact on bank reserves. Indeed, Asian central banks that have seen their balance sheets expand in recent years with the sustained accumulation of foreign reserves have, on the whole, been able to maintain their interest rate targets. Disyatat (2008) provides further discussion of these issues.

constrained and it was necessary to expand the capacity of reserve-draining instruments on the liability side.

During the fall of 2008, the assets of the Federal Reserve and the Bank of England more than doubled in a matter of weeks, while those of the European Central Bank increased by more than 30 percent (Chart 2). In the case of the Federal Reserve, the growth in assets was driven by larger term operations, new lending facilities, and dollar swaps with other central banks.

For the European Central Bank and the Bank of England, the expansion was driven mainly by repos and auctions of dollar liquidity. On the liability side, the increase in balance-sheet capacity of the Federal Reserve came from bank reserves and a one-off injection in the Treasury account (Chart 3). For the European Central Bank, the primary offsetting instrument has been the deposit facility, whereas the Bank of England has increasingly relied on the issuance of central bank bills.

Chart 2
Central Bank Assets
Billions of National Currency



Sources: Central banks; Datastream.

[a] Securities held outright (including Term Securities Lending Facility).

[b] Repurchase agreements, term auction credit, and other loans.

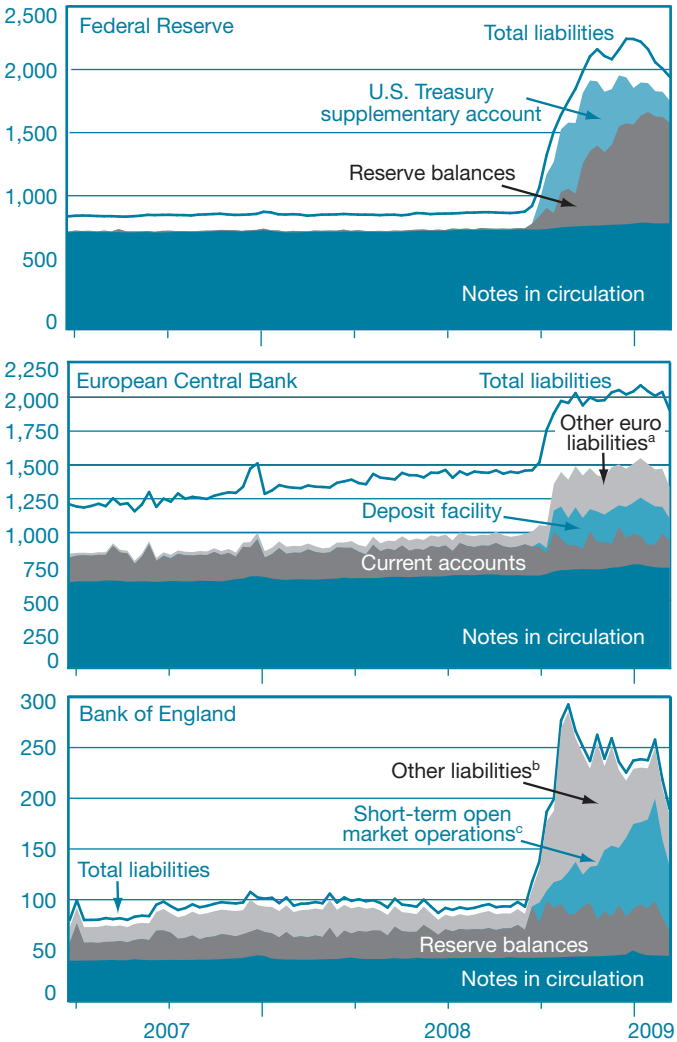
[c] Including U.S. dollar liquidity auctions.

[d] Of euro area residents and general government debt in euros.

[e] Including repos and other lending in euros.

[f] Short- and long-term reverse sterling repos.

Chart 3
Central Bank Liabilities
Billions of National Currency



Sources: Central banks; Datastream.

[a] To other euro-area and non-euro-area residents, including central banks.

[b] Including to central banks.

[c] Including issuance of Bank of England sterling bills.

5. Conclusion

One hundred and thirty-five years ago, Walter Bagehot wrote that, to stay a banking panic, 1) the bank supplying reserves "must advance freely and vigorously to the public," 2) "these loans should only be made at a very high rate of interest," and 3) "at this rate these advances should be made on all good banking securities, and as largely as the public ask for them" (1873, pp. 74-5). From these basic principles, central banks derived the theory of the lender of last resort. But Bagehot lived in a different world—not only were there no automobiles, airplanes, or computers, but there were very few central banks—fewer than 20, whereas today there are more than 170. Since central banks are essentially a twentieth-century phenomenon, it is natural to ask whether Bagehot's nineteenth-century doctrine still applies.

In this paper, we have argued that Bagehot's view of the lender of last resort requires modification. As the financial system has gained in complexity, so have all facets of the role of central banks. Following the trail blazed by Bagehot, we refine the theory of the LOLR by identifying three types of liquidity shortages that can occur in the modern financial system: 1) a shortage of central bank liquidity, 2) an acute shortage of funding liquidity at a specific institution, and 3) a systemic shortage of funding and market liquidity.

Our analysis leads us to conclude that the appropriate principles for central banks' LOLR support must be conditioned on the particular type of liquidity shortage that is taking place. When confronted with a simple shortage of central bank liquidity, for example, Bagehot's dictum applies. By contrast, a systemic event almost surely requires lending at an effectively subsidized rate compared with the market rate while taking collateral of suspect quality.

In the same way, any discussion of communication policy in the potential future application of LOLR policy, such as the desirability of constructive ambiguity, must be linked to a specific type of liquidity shortage. So, for example, while ambiguity of access to central bank liquidity may be an important countervailing force against moral hazard in situations of acute institution-specific liquidity shortages, it is likely to be counterproductive when it comes to dealing with general shortages of central bank liquidity or while in the midst of a systemic crisis.

In terms of the debate outlined earlier on the appropriate form of LOLR lending, the current crisis has made it abundantly clear that the argument that only open market operations are needed to meet the liquidity needs of fundamentally sound banks is flawed since money markets themselves can fail to function properly. This is even more so in light of recent developments in the financial system that have increased the interdependencies between financial institutions and markets, and made it more imperative that central banks be prepared for situations in which both experience problems simultaneously.

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Erhan Artuç and Selva Demiralp

Provision of Liquidity through the Primary Credit Facility during the Financial Crisis: A Structural Analysis

1. Introduction

In response to the liquidity crisis that began in August 2007, central banks designed a variety of tools for supplying liquidity to financial institutions. The Federal Reserve introduced several programs, such as the Term Auction Facility, the Term Securities Lending Facility, and the Primary Dealer Credit Facility, while enhancing its open market operations and discount window. This paper focuses on the financial market effects of changes to the discount window borrowing facility. Specifically, we investigate whether the changes represent a fundamental shift in the way the Federal Reserve traditionally provided liquidity through the primary credit facility as well as whether the Fed would be well served to retain these changes to its borrowing facility indefinitely.

In January 2003, the Federal Reserve revised its discount window lending program. The revision was designed to improve the operation of the facility, which had experienced declines in usage. Before 2003, borrowing from the Fed took place at a rate below the market rate, known as the discount rate. Fed officials applied a non-price funds-rationing mechanism by asking potential borrowers detailed questions about their financial well-being before lending funds. This administrative process deterred depository institutions from using the discount window because borrowing from the Fed was perceived as a signal of financial weakness by market participants.[1]

The revised discount window borrowing facility was designed to eliminate the reluctance to borrow from the Fed by including a new "no-questions-asked" policy for eligible borrowers. However, despite Fed assurance that the new facility would eliminate all administrative costs of borrowing, some argued that the stigma could not be eliminated completely (see, for example, Furfine [2001, 2003]). However, Artuç and Demiralp (2010) recently showed that the stigma of borrowing declined substantially in the post-2003 period, following the easing of the Fed's administrative policy and restrictions.

In this paper, we assess the effects of changes to the primary credit facility since August 2007 by performing out-of-sample simulations based on a model developed by Artuç and Demiralp (2010). Our results are highly consistent with the predictions of our 2008 study—that is, the revised discount window is effective and plays an essential role in moderating volatility in the federal funds market.

[1] See, for example, Goodfriend (1983), Pearce (1993), Dutkowsky (1993), Peristiani (1998), Clouse and Dow (1999), Furfine (2003), Dow (2001), and Darrat et al. (2004).

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2. Recent Changes to the Primary Credit Facility

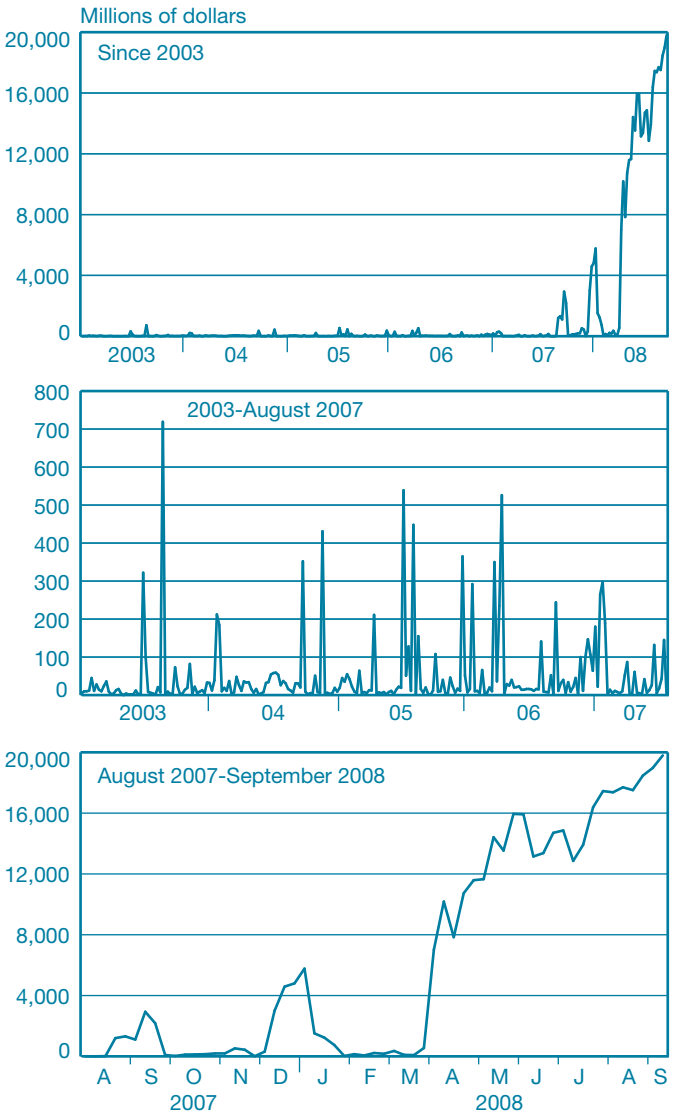
The primary credit facility, as revised by the Federal Reserve in 2003, offered credit to financially sound banks at a rate 100 basis points above the Federal Open Market Committee's target federal funds rate (the primary credit rate). Primary credit was made available to depository institutions at an above-market rate but with very few administrative restrictions and no limits on the use of proceeds (see Madigan and Nelson [2002]). Because the interest rate charged on primary credit was above the market price of funds, it replaced the rationing mechanism for obtaining funds from the central bank and eliminated the need for administrative review by the Federal Reserve.

Amid the onset of the liquidity crisis in August 2007, the Federal Reserve lowered the spread between the primary credit rate and the target funds rate from 100 basis points to 50 basis points and extended the maximum term of loans to thirty days. In March 2008, the Fed once again narrowed the spread, this time to 25 basis points, and extended the loan term to ninety days. The moves were motivated by the desire to make discount window credit more accessible to depository institutions.

The Federal Reserve's actions led to an increase in the volume of discount window borrowing during the crisis (Chart 1). The upper panel of the chart shows total primary credit outstanding since the establishment of the revised facility in 2003. The middle and lower panels, which split the sample at August 2007, illustrate the enormous rise in borrowing that occurred.

While the massive increase in the volume of borrowing supports the argument that the stigma of borrowing had been eliminated, one should be cautious when interpreting this result. Chart 2, which plots the highest traded funds rate against the primary credit rate, shows that despite the expansion in borrowing, some trades in the funds market took place at rates above the primary credit rate. What is reassuring about these findings, however, is their consistency with the predictions of our earlier work. As Artuç and Demiralp (2010) describe, reluctance to borrow from the Fed has several components. The non-price mechanism is the component attributable to the Federal Reserve's implementation of discount lending. Artuç and Demiralp show that this component declined significantly after the establishment of the revised facility in 2003. Meanwhile, a second type of stigma arises from the asymmetric information problems associated with discount window borrowing. Specifically, while most banks borrow from the discount window, the facility is also used by troubled or failing institutions. Because market participants cannot fully differentiate sound from troubled

Chart 1
Primary Credit Outstanding
Weekly Average



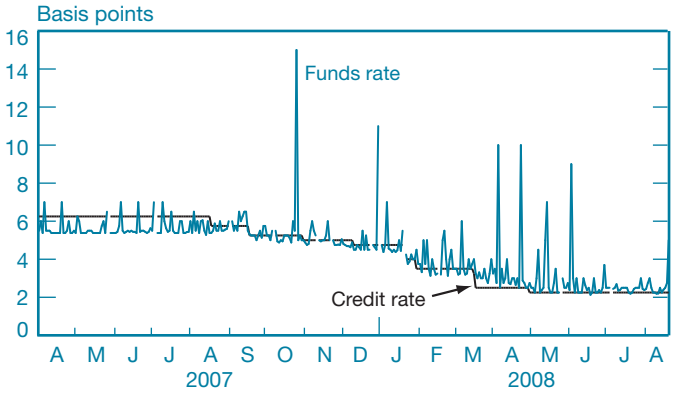
Source: Federal Reserve Statistical Release H.4.1.

borrowers, they may view borrowing as a potential sign of weakness of any bank that visits the window. If this type of stigma increases at the early stages of a financial crisis, when institutions are trying to signal their good health, it could explain the spikes in the funds rate over the primary credit rate shown in Chart 1.[2] In addition, it is plausible that the capital crunch during the financial crisis left some institutions without sufficient collateral to apply for primary credit loans and thus forced them to bid for higher rates in the federal funds market, which is unsecuritized.

Chart 2

Daily High Funds Rate and Primary Credit Rate

Weekly Average



Sources: Daily high funds rate: Federal Reserve Bank of New York (http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); primary credit rate: Federal Reserve Statistical Release H.15.

3. The Model

The model we describe closely resembles the one developed in Artuç and Demiralp (2010), which can be viewed as an extension of the model proposed by Clouse and Dow (1999). Hence, our discussion relies heavily on Section 3 of Artuç and Demiralp (2010). We consider a framework in which bank *i*'s goal is to keep its daily reserves holdings at a level L_1. Daily reserve balances vary over the course of the maintenance period (see Carpenter and Demiralp [2006]). However, from the borrower's perspective, a bank's decision to borrow from the Fed is static based on liquidity conditions each day. Therefore, we do not differentiate across days of the maintenance period except for the settlement Wednesday, which may necessitate higher borrowing because banks have less flexibility in absorbing any reserve shortages on the last day of the maintenance period. On this day, the desired level of reserve holdings is determined by L_2.

Banks' balance holdings follow a stochastic process. During the day, there are aggregate and individual shocks to the average level of reserve balances ($\bar{R}$), which sets the balance of bank *i* equal to:

$$R_t^i = \bar{R} + U_t + V_t^i, \quad (1)$$

where $U_t \sim N[0, X_U]$ is an aggregate shock[3] and $V_t^i \sim U[-X_v, X_v]$ is an individual shock where X_U is the standard deviation of the aggregate shock while X_V represents the support of the mean zero uniform distribution. Hence, the individual bank becomes a lender in the funds market if $R_t^i > L$ and demands funds if $R_t^i < L$ for $L = L_1, L_2$.

Banks that are short of reserves have two options: they can either borrow from the funds market or from the Federal Reserve. If the bank chooses to borrow ϕ_t dollars from the funds market, the cost per dollar is the market interest rate r_t. Alternatively, if the bank borrows ϕ_t dollars from the Federal Reserve, the cost per dollar is the discount rate (or the primary credit rate after 2003), r_f, plus a fixed cost *c*. Thus, total cost per dollar is $r_f + \frac{c}{\phi_t}$. Because of the fixed cost, partial borrowing from the Federal Reserve is not optimal, and a bank either prefers to borrow entirely from the Federal Reserve or from the funds market.[4]

In addition to borrowing from the Federal Reserve because of market conditions, banks borrow because of technical difficulties, such as network problems that force them to use the Fed regardless of market conditions. To capture this type of borrowing, we assume that a random fraction of banks, p_t, will face a technical problem in the system where p_t has a uniform distribution: $p_t \sim U[0, F]$.

We assume that there is a continuum of banks, indexed from 0 to 1. Thus, there are an infinite number of banks with zero individual measure whose measure integrates to 1. We index according to reserve balance levels, such that a bank with the lowest level of reserve balances is indexed to 0 and one with the highest level of reserve balances is indexed to 1.

Total demand for funds has two components: It can be met in the funds market or it can be met at the discount window. The equilibrium federal funds rate, r_t, is determined by the market equilibrium when the total supply of funds is equal to the total demand for funds. In modeling borrowing behavior, our focus is on individual trades in the funds market and on days of market tightness because borrowing from the Fed on

[2] Indeed, a closer look at the days with spikes in the funds rate reveals that market commentaries are consistent with elevated asymmetric information problems. An extreme example is October 25, 2007, when the highest traded funds rate exceeded the primary credit rate by almost 10 percentage points. On that date, Wrightson ICAP reported that "the stigma of discount window borrowing was heightened by the news that the New York Fed had extended $400 million of secondary-credit loans on Wednesday. If word got out that a given institution had tapped the window on Thursday, the market might speculate that the bank in question was the same one that had been forced to make use of the higher-cost secondary credit program for shaky institutions the day before. The reputational damage of a leak of that nature would be disastrous" (Wrightson ICAP, *Fed Funds Monitor*, http://www.wrightson.com).

[3] Because the original model is estimated by removing the outliers, we subtract 0.5 percent from the tails of the normal distribution.

[4] Without loss of generality, one may think of the fixed costs of borrowing as varying by bank, reflecting each bank's relative reluctance to borrow from the discount window based on factors such as the size of the borrowing, the history of borrowing, or the availability of credit lines in the funds market. While we model it in a homogenous manner for simplicity, modeling it in a heterogeneous manner is also trivial and does not change any implications of our model.

these days is more likely. Therefore, we set the daily high funds rate equal to:

(2) $$r_t^{high} = r_t + \omega_t \text{ where } \omega_t \sim (0, s).$$

Equation 2 shows that the maximum funds rate registered for a given day will differ from the equilibrium funds rate depending on the reserves need and the bargaining power faced by the counterparties of that particular trade, represented by ω_t.

Turning to the days without market tightness, we note that trades are almost always cleared in the funds market unless there is a technical problem. For that reason and without loss of generality, if supply is larger than demand, we simply set the funds rate (r_t) equal to the marginal benefit of holding balances, as in Clouse and Dow (1999). Hence, a bank can offer reserves in the funds market if the market rate is greater than the marginal benefit of holding balances.

If the fixed costs of borrowing decline in the period after 2003, then, all else equal, it implies a decline in the volatility of the funds rate in the post-2003 period and an increase in the sensitivity of discount window borrowing to the funds rate. (A more detailed discussion of the implications of the model can be found in Artuç and Demiralp [2010].) This implied change in volatility and the revival of the borrowing function allow us to identify the size of the implicit cost before and after 2003.

If we could attribute the entire decline in fed funds volatility to the revised discount facility, we could proceed with estimation without any second thoughts. However, the decline in fed funds volatility is also influenced by other developments, such as enhanced liquidity management by the Federal Reserve's Trading Desk (see Demiralp and Farley [2005]), improvements in internal information systems (including those that track a bank's Federal Reserve account balance), or banking industry consolidation. To minimize the effects of such factors on fed funds volatility, we keep our sample period relatively recent, starting it in 1998. Furthermore, to control for any remaining effects of such factors, we allow the distributions of U_t and V_t^i to widen or narrow in a linear fashion over time. That is, we let:

(3) $$X_U = A + D \times t \quad \text{and} \quad X_V = B + E \times t \ ,$$

where t is the time trend, X_U and X_V are defined after equation 1.

To identify the potential decrease in the stigma associated with discount window borrowing, we consider the following specification for the implicit borrowing cost c:

$c = c_1$, prior to 2003

$c = c_1 + c_2$, after 2003.

Note that the above specification treats the implicit costs of borrowing as exogenously determined. An alternative and more plausible strategy would be to model the costs of borrowing as a function of the amount borrowed from the Federal Reserve. However, modeling the cost of borrowing endogenously cannot be identified in this study, so the issue remains a topic for future research.[5]

To estimate our model, we rely on "indirect inference," which uses the estimates of an auxiliary model (rather than moments) to compare actual and simulated data. Because we can think of data moments as the parameters of a simplified auxiliary model, Method of Simulated Moments (or GMM) can be considered special cases of indirect inference. An auxiliary model does not need to be "correct" for indirect inference to yield consistent results. As long as the selected auxiliary model summarizes the data well, the estimates of the actual model will be consistent and asymptotically normal. This is because the auxiliary model is used only to extract information on the underlying data-generating process and, provided that the parameter estimates from the actual data are close to those from the simulated data, whether both estimates are biased or not is of secondary importance. In other words, the auxiliary parameter estimates themselves do not carry much meaning other than being indicators of how closely the simulations match the data (see Artuç and Demiralp [2010]; for a more technical reading on indirect inference, see Gourieroux, Monfort, and Renault [1993] and Smith [1993]).

We contemplate a simple borrowing function as the auxiliary model. The auxiliary borrowing function summarizes how borrowing from the Fed changed over time and after the policy change in 2003 through a simple ordinary least squares (OLS) regression, shown in equation 4. In addition to OLS estimates, we use the mean and the variances of borrowing and the spread between the daily high funds rate and the target as part of the auxiliary model (equations 5-8). We also add the lowest 50 percent of the spread between the daily high funds rate and the target to capture funds rate volatility in the absence of market tightness (equations 9 and 10). The estimation strategy is to find the parameters that will make the simulations of the model and the actual data look as similar as possible with respect to the auxiliary model's OLS estimates and moments. Specifically, our auxiliary model is:

(4) $$BR_t = \beta_1 + \beta_2 \tilde{r}_t + \beta_3 t + \beta_4 t\tilde{r}_t + \beta_5 D^{2003}\tilde{r}_t + \beta_6 D^{\text{Settl. Wed.}} + \varepsilon_t$$

(5) $$BR_t = \beta_7 + \varepsilon_{2t}$$

(6) $$\tilde{r}_t = \beta_8 + \varepsilon_{3t}$$

(7) $$(BR_t - \beta_7)^2 = \beta_9 + \varepsilon_{4t}$$

(8) $$(\tilde{r}_t - \beta_8)^2 = \beta_{10} + \varepsilon_{5t}$$

[5] We thank Carolyn Wilkins for bringing this point to our attention.

(9) $$\tilde{r}_{2t} = \beta_{11} + \varepsilon_{6t}$$

(10) $$(\tilde{r}_{2t} - \beta_{11})^2 = \beta_{12} + \varepsilon_{7t}$$

and

$$\beta = [\beta_1 \beta_2 \ldots \beta_{12}],$$

where BR_t is the amount of borrowing from the Fed normalized by required operating balances, $\tilde{r}_t$ is the spread between the funds rate and the funds rate target, t is the time trend, D^{2003} is a dummy for days after the policy change, $D^{Settl.\ Wed.}$ is a dummy for the settlement Wednesday, ε_t is an *iid* random shock, T is sample size, and $\tilde{r}_{2t}$ is the lowest 50 percent of $\tilde{r}_t$.

Let $\hat{\beta}$ be an OLS estimate of β from the actual data and $\tilde{\beta}$ be an estimate of from the simulated data. We select the model's parameters $[ABc_1c_2DEF\bar{R}sL_2|]$ such that $(\hat{\beta} - \tilde{\beta})\, W\, (\hat{\beta} - \tilde{\beta})'$ is minimized, where W is the weighting matrix that is equal to the inverse of the covariance matrix of β .

In estimating the model, we exclude those days on which the daily high funds rate exceeds the target rate by more than 25 percent to obtain a more realistic distribution of shocks. Our estimation results, presented in the appendix, suggest that the implicit fixed cost of borrowing declines about 90 percent (from 0.054 to 0.007) after the policy change in 2003. This result offers strong evidence that the Fed's new policy was indeed successful in reducing the stigma associated with discount window borrowing.

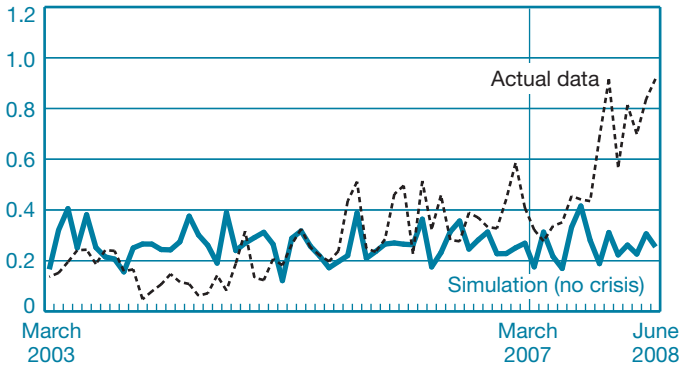
4. Simulation Analysis

In this section, we use our model to analyze the role of the Federal Reserve's primary credit lending facility in stabilizing the money markets in the face of the liquidity crisis. Specifically, we ask the following questions:

1. What are the effects of the establishment of the revised lending facility on total borrowing and interest rates? In particular, how would the crisis picture look if the implicit costs of borrowing had not been reduced with the new regime in 2003?
2. What are the implications of the increased term of discount lending in the funds markets?
3. What are the effects of narrowing the spread between the primary credit rate and the target rate in stabilizing the money markets?
4. What are the implications for discount window borrowing of paying interest on reserves?

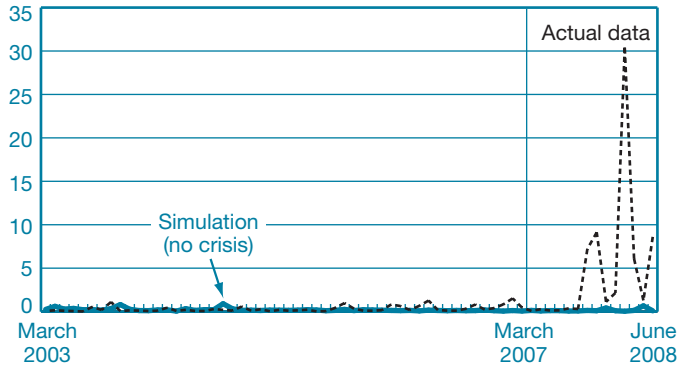
Recall that the model described earlier is designed to capture the "normal times" of healthy functioning markets. Our estimation period captures a period of a relatively stable structural environment. The sample starts on June 30, 1998, with the switch from contemporaneous reserves accounting to lagged reserves accounting. It ends on March 19, 2007, a few months prior to the onset of the liquidity crisis in August 2007. Indeed, if we use the estimates from our model for out-of-sample simulations, the severity of the crisis and the model's inability to forecast this environment become clear. Charts 3 and 4 compare actual data with the model's out-of-sample simulations for the deviation of the daily high funds rate from the target and for primary credit outstanding, respectively.

Chart 3
Daily High Funds Rate Less Target



Sources: Federal Reserve Bank of New York (daily high funds rate: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); (target: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); simulated series: authors' calculations.

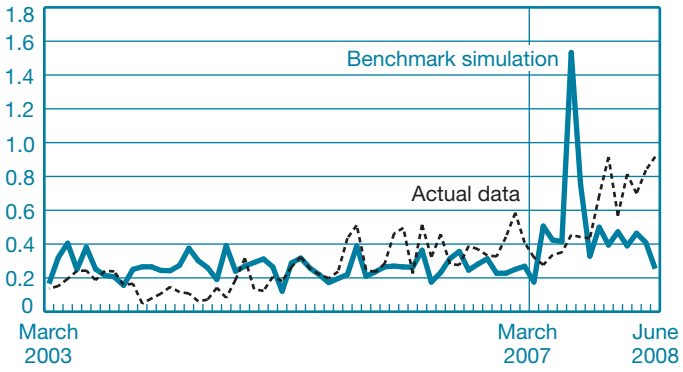
Chart 4
Primary Credit Outstanding
Normalized with Required Operating Balances



Sources: Primary credit outstanding: Federal Reserve Statistical Release H.4.1; required operating balances: Federal Reserve Board; simulated series: authors' calculations.

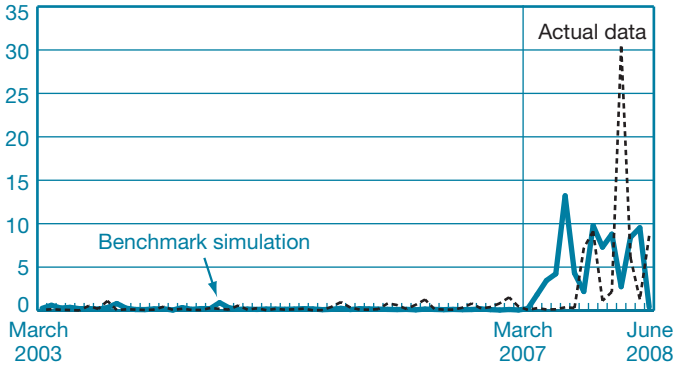
Note: Required operating balances is the sum of required reserve balances and contractual clearing balances.

Chart 5
Daily High Funds Rate Less Target (with Benchmark Simulation)



Sources: Federal Reserve Bank of New York (daily high funds rate: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); (target: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); simulated series: authors' calculations.

Chart 6
Primary Credit Outstanding (with Benchmark Simulation)
Normalized with Required Operating Balances



Sources: Primary credit outstanding: Federal Reserve Statistical Release H.4.1; required operating balances: Federal Reserve Board; simulated series: authors' calculations.

Note: Required operating balances is the sum of required reserve balances and contractual clearing balances.

While it is a daily model, we present the results in terms of monthly averages for visual clarity. The vertical line in each chart corresponds to the end of our estimation period in March 2007. There is a wide discrepancy between the data and the model's simulations, indicating that the period after August 2007 represents quite extraordinary circumstances that cannot be captured by the estimates prior to August 2007, as we would expect.

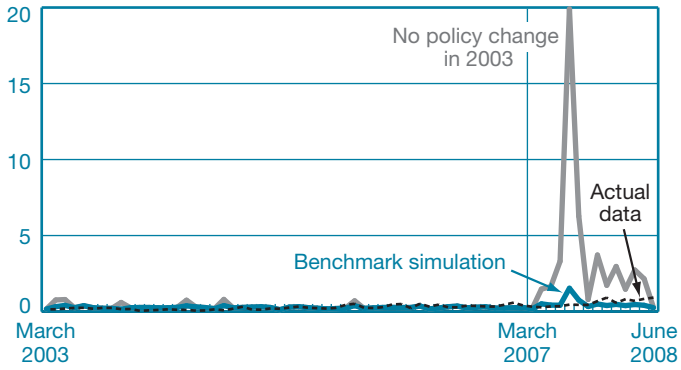
The sizable discrepancy between the data and the simulations for the crisis period suggests that we should incorporate the crisis circumstances into our model before we can conduct counterfactual experiments on the efficiency of the Federal Reserve's policies. At this point, we make several assumptions to replicate conditions during the crisis. To capture the overall need for short-term liquidity, we increase the volatility of the aggregate shock U_t. Furthermore, the increase in the term of the borrowing is expected to reduce the implicit costs of borrowing by making it more convenient to lengthen the duration of a loan.[6]

To match the moments of the data, we double the standard error of the aggregate shock U_t and reduce the costs of borrowing by one half, which allows us to obtain more reasonable estimates for the interest rate spread and the volume of borrowing during the crisis period (Charts 5 and 6). We call these simulations the "benchmark simulations." In evaluating the model's performance, one should be careful not to use the "eyeball metric" to compare the simulated series with the actual data, because it gives the wrong impression that the model's goal is to match the actual data on a day-by-day basis. Instead, our goal is to match the underlying data-generating process, and our estimation results, presented in the appendix, show that the model does reasonably well in achieving this goal. Indeed, even if we match the underlying data-generating process perfectly, the simulated series will differ from the actual data because of the presence of random shocks.

We now analyze the questions raised at the beginning of this section. The first involves the effects of the 2003 policy change on mitigating the crisis after 2007. In other words, had the Fed not changed its lending policy in 2003, how would the funds market look? Based on our findings in Artuç and Demiralp (2010), we would expect funds market volatility to worsen significantly in the absence of the new regime because the current practice allows institutions in need of funds to utilize this service without much hesitation. Chart 7 confirms our expectations. The chart plots the actual spread between the daily high funds rate and the target (the dashed line) as well as the simulations generated by our benchmark model (the blue line). In addition, it shows the spread under the counterfactual experiment, where the cost of borrowing remains at its pre-2003 level (the gray line). As the chart reveals, the counterfactual series skyrockets during the crisis period, suggesting that the Federal Reserve's switch to the new lending

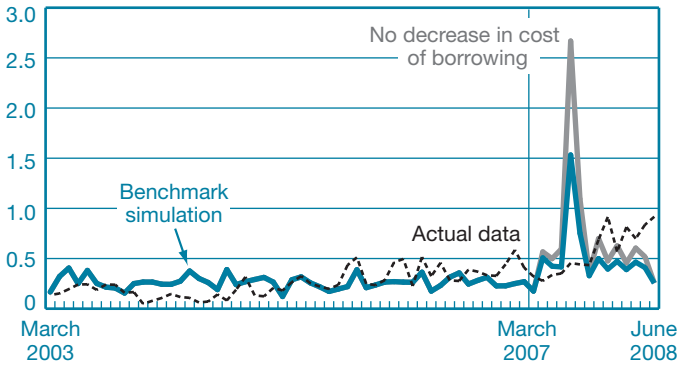
[6] The Federal Reserve may have also reduced the implicit costs of discount borrowing indirectly by introducing several other lending facilities and making overall borrowing more accessible.

Chart 7
Daily High Funds Rate Less Target
(with No Policy Change in 2003)



Sources: Federal Reserve Bank of New York (daily high funds rate: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); (target: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); simulated series: authors' calculations.

Chart 8
Daily High Funds Rate Less Target
(with No Decrease in Cost of Borrowing)



Sources: Primary credit outstanding: Federal Reserve Statistical Release H.4.1; required operating balances: Federal Reserve Board; simulated series: authors' calculations.

Note: Required operating balances is the sum of required reserve balances and contractual clearing balances.

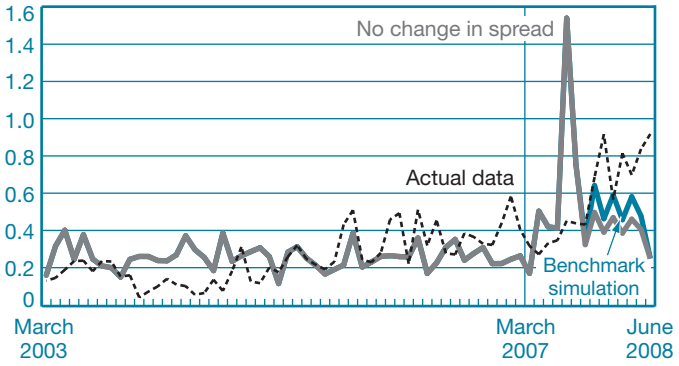
regime was very effective in containing the severity of the crisis in the money markets.

Turning from prices to quantities, we note that the volume of borrowing cannot differ between the two regimes because in our model banks have to borrow the necessary amount of reserve balances to avoid an overdraft or a reserve deficiency. For this reason, in reporting our simulation results, we present only the spread between the daily high funds rate and the target rate and not the borrowing behavior when the latter is unaffected under different scenarios.

Next, we analyze the effectiveness of changes in the primary credit facility that the Federal Reserve introduced at the beginning of the crisis. Recall that our benchmark model implies a 50 percent decline in borrowing costs during the crisis period. In assessing the implications of extended terms of borrowing, we keep the fixed cost of borrowing at its precrisis level and simulate the interest rate spread under this scenario. Chart 8 displays our results. The elevated volatility under the counterfactual scenario indicates that extending the borrowing term was an effective action in reducing the implicit costs of borrowing and hence controlling funds market volatility.

In addition to extending the borrowing term, the Federal Reserve also narrowed the spread between the primary credit rate and the target rate from 100 basis points to 25 basis points during the crisis. Our earlier findings in Artuç and Demiralp (2010) would suggest that the primary credit rate works as an upper bound in the absence of market stigma and that a decline in this rate should decrease deviations of the funds rate from the target. Our next simulation keeps the spread between the primary credit rate and the target unchanged at 100 basis points. As shown in Chart 9, the counterfactual spread is at least as high as the benchmark simulation, if not higher. This elevated volatility suggests that the narrowing of the spread was an effective action, even though the difference between the counterfactual and benchmark simulations is not as outstanding as in the previous exercises, probably because of the increased need for collateral under the crisis conditions. That is, because federal funds borrowing is unsecuritized, whereas discount window borrowing requires collateral,

Chart 9
Daily High Funds Rate Less Target
(with No Change in Spread)



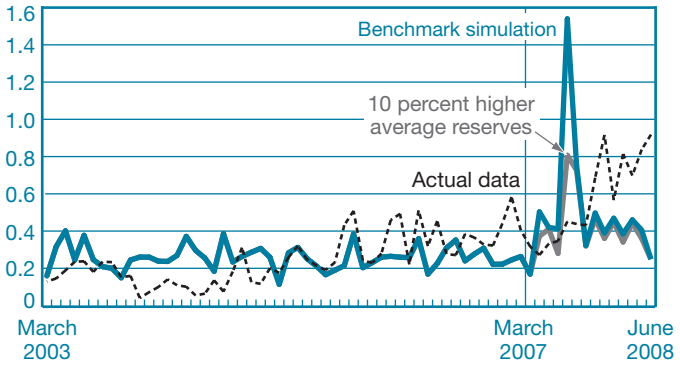
Sources: Federal Reserve Bank of New York (daily high funds rate: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); (target: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); simulated series: authors' calculations.

certain banks may still need to borrow in the funds market and pay a higher premium if they lack sufficient collateral for discount borrowing.

Recently, the Federal Reserve has been granted the authority to pay interest on reserve balances. In addition to placing a theoretical lower bound on the funds rate, interest payments on reserve balances may increase the demand for balances simply because the cost of holding these balances has been reduced. Our last exercise considers the impact of a higher level of balances on controlling funds rate volatility. While it is difficult to estimate the precise magnitude of the change in reserve balances, we increase the average normalized reserve balances by 10 percent in our counterfactual experiment. Chart 10 shows that control over interest rates improves while Chart 11 shows that the need for borrowing declines if the average balance holdings increase, as predicted under this new regime. Together, these results suggest that any policy change that leads to an increase in reserve holdings, such as interest payments on reserves, is useful in stabilizing the money markets.

Chart 10

Daily High Funds Rate Less Target
(with 10 Percent Higher Average Reserves)

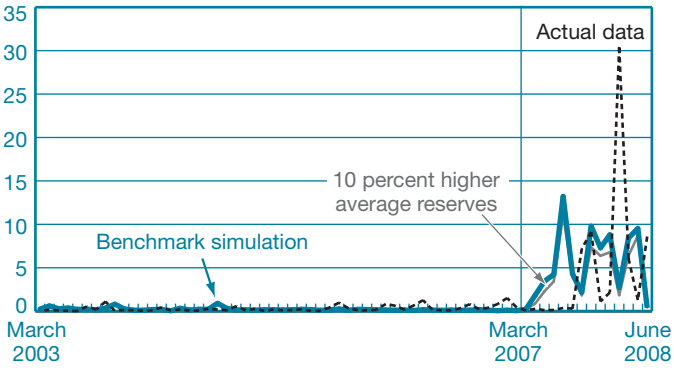


Sources: Primary credit outstanding: Federal Reserve Statistical Release H.4.1; required operating balances: Federal Reserve Board; simulated series: authors' calculations.

Note: Required operating balances is the sum of required reserve balances and contractual clearing balances.

Chart 11

Primary Credit Outstanding
(with 10 Percent Higher Average Reserves)
Normalized with Required Operating Balances



Sources: Federal Reserve Bank of New York (daily high funds rate: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); (target: http://newyorkfed.org/markets/omo/dmm/fedfundsdata.cfm); simulated series: authors' calculations.

5. Conclusion

This paper analyzes the effectiveness of various changes adopted by the Federal Reserve since the onset of the liquidity crisis in August 2007. We show that the steps taken to reduce the implicit costs of borrowing were more effective in stabilizing the money markets while the narrowing of the spread between the primary credit rate and the target was not as effective.

Would the Federal Reserve be well served to retain these changes to its borrowing facility indefinitely? Our results suggest that the spread between the primary credit rate and the target rate could be increased back to 100 basis points without much impact on the financial markets. Meanwhile, the recent policy change of paying interest on reserves should make it easier for the Federal Reserve's Trading Desk to maintain the target permanently, not only by placing a lower bound on the funds rate, but also by increasing the level of reserve balances—which should reduce the demand for borrowing and ease the resulting tightness in the funds markets.

Appendix

Panels A and B of the table on the next page present ordinary least squares estimates of the auxiliary model parameters using actual as well as simulated data along with the mean and the variance of borrowing and $\tilde{r}_t$. Comparing columns 2 and 4 of panel A, we note that the auxiliary model's estimates from the simulated data and the actual data are fairly similar, as the algorithm minimizes the distance between those two estimates. However, they are not identical, as the auxiliary model has more parameters than the true underlying model. As shown in row 5, borrowing responsiveness to the interest rate spread ($\tilde{r}_t$) increases significantly after the Federal Reserve policy change in 2003, consistent with a decline in market stigma associated with discount window borrowing and the revival of the borrowing function. Panel B provides a similar comparison between the moments generated by the actual data (column 2) and those computed from the simulated data (column 3). Similar to panel A, the two sets of statistics display a strong resemblance.

Panel C presents the parameter estimates of the true underlying model and their standard errors. The most interesting parameters for our purposes are displayed in rows 1 and 2. Notice that the implicit fixed cost of borrowing declines about 90 percent (from $c_1 = 0.054$ to $c_1 + c_2 = 0.007$) after the policy change in 2003. This result provides strong evidence that the Fed's new policy was indeed successful in reducing the stigma associated with discount window borrowing. In addition to estimating the fixed cost of borrowing from the discount window, we are also interested in determining whether this implicit cost exhibits any gradual changes over time. In particular, one may expect a gradual decline in the implicit cost of borrowing in the post-2003 period because of the market's slow adjustment to the new regime. To address this issue, we experimented with an alternative model that allows for a time trend in the implicit cost of borrowing prior to and after 2003 (not shown). However, the trend terms associated with the implicit cost of borrowing were not significant in either sample. This finding suggests that there may not be a gradual adjustment to the new regime in the second sample. Our results may also be driven by the fact that we may not have a sufficient number of observations to identify such a time trend.

Row 3 of panel C shows that the aggregate reserve shock U_t ranges between -0.43 and 0.43 in the beginning of the sample, while row 4 shows that the bank-specific reserve shock V_t^i varies between -0.34 and 0.34 initially. Rows 5 and 6 show that there is a significant time trend in these shocks. In fact, when we substitute the estimates for *D* and *E* in equation 3, we observe that the aggregate reserve shock exhibits a negative trend while the bank-specific shock exhibits a positive trend. The estimate of *E* implies that the standard error of U_t decreases about 0.05 percent per year while the estimate of *D* implies that the range of V_t^i increases about 15 percent each year. The mild negative time trend in the aggregate shock, U_t, could reflect improvements in the Federal Reserve Trading Desk's reserve management ability over time, as we observe in this paper.

Row 7 of panel C shows that the estimated ratio of banks that incur a technical problem, and thus are forced to borrow from the Fed rather than the markets, varies from 0 to 0.04. This result indicates that no more than 4 percent of banks are affected by this type of condition at any time. Row 10 indicates that banks seek to attain a higher level of balances on the last day of the maintenance period, consistent with our expectations.

Auxiliary Model and Indirect Inference Estimations

Panel A: Auxiliary Model Ordinary Least Squares Regression

	Actual Data		Simulated Data	
	Coefficient	Standard Error	Coefficient	Standard Error
1. Constant	0.48**	0.07	0.53**	0.04
2. $\tilde{r}_t$	0.26**	0.05	0.35**	0.03
3. t	-0.04**	0.01	-0.05**	0.004
4. $t \times \tilde{r}_t$	0.06**	0.01	0.05**	0.005
5. $D^{2003} \times \tilde{r}_t$	0.86**	0.22	1.01**	0.10
6. $D^{Settl.Wed.}$	0.46**	0.11	0.48**	0.07

Panel B: Auxiliary Model Moments

	Actual Data	Simulated Data
1. Mean(BR)	0.46	0.45
2. Mean($\tilde{r}_t$)	0.42	0.37
3. Mean($\tilde{r}_{2t}$)	0.25	0.25
4. Var(ζ)	3.01	2.15
5. Var($\tilde{r}_t$)	1.14	1.93
6. Var($\tilde{r}_{2t}$)	0.14	0.08

Panel C: Indirect Inference Estimation

	Coefficient	Standard Error
1. c_1	0.0541**	0.002
2. c_2	-0.0485**	0.004
3. A	0.4257**	0.001
4. B	0.3432**	0.0008
5. D	-0.0010**	0.0005
6. E	0.2001**	0.0007
7. F	0.0421**	0.0004
8. $\overline{R}$	0.8594**	0.0034
9. s	0.0027	0.00001
10. L_2	0.4828	0.0016

Where:

BR	normalized borrowing from the Federal Reserve
$\tilde{r}^t$	daily high funds rate minus target rate
$\tilde{r}_{2t}$	lowest 50 percent of daily high funds rate less target rate
t	time trend
D^{2003}	dummy variable for period after January 6, 2003
$D^{Settl.Wed.}$	dummy variable for last day of maintenance period
c_1	implicit cost prior to 2003
c_2	implicit cost after 2003
A	interval parameter for aggregate shock
B	interval parameter for bank-specific shock
D	time trend parameter for aggregate shock
E	time trend parameter for bank-specific shock
F	interval parameter for probability of technical problem
$\overline{R}$	average reserve balances
s	variance of noise parameter for daily high funds rate
L_2	implicit reserve target on last day of maintenance period

Source: Authors' calculations.

* Statistically significant at the 95 percent confidence level.
** Statistically significant at the 99 percent confidence level.

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Asani Sarkar and Jeffrey Shrader

Financial Amplification Mechanisms and the Federal Reserve's Supply of Liquidity during the Financial Crisis

1. Introduction

One of the primary questions associated with the recent financial crisis is how losses on subprime mortgage assets of approximately $300 billion[1] led to rapid and deep declines in the value of a wide range of other financial assets and, increasingly, real economic output. The disproportionate amount of total losses compared with the relatively small size of the initial trigger points to the presence of amplification mechanisms that allowed losses centered in one market to cause a systemwide downturn. A further question is why subprime mortgage-backed securities (MBS) in particular, rather than any other asset, led to the downturn. Identifying key factors leading to the crisis, Blanchard (2009) cites the interaction between general market conditions, such as high leverage, underpricing of risk, and high interconnectedness, and certain features of subprime MBS, such as opacity, as well as investors' belief in ever-rising housing prices.[2]

In this paper, we examine how the conditions identified by Blanchard and other researchers led to widespread losses in financial markets. Our study focuses on two financial amplification mechanisms of relevance to the crisis: balance-sheet amplifiers and adverse-selection amplifiers.[3] We also interpret the actions of the Federal Reserve in the context of the literature on financial amplification mechanisms as well as provide new empirical evidence on the effectiveness of the Fed's liquidity supply during the crisis.

The balance-sheet mechanism is often cited as an explanation for liquidity crises. For example, it has been used to explain the stock market crash of 1987 (Brunnermeier and Pedersen 2009), the Long-Term Capital Management (LTCM) crisis of 1998 (Gromb and Vayanos 2002), and the current crisis (Bernanke 2009). Indeed, the Bank of England incorporates this mechanism into its quantitative Risk

[1] See the International Monetary Fund's "Global Financial Stability Report," April 2008.

[2] Acharya and Richardson (2009), Adrian and Shin (forthcoming), Brunnermeier (2009), and Gorton (2008), among others, also describe the genesis of the crisis and provide explanations for how it was propagated.

[3] For our discussion, a financial amplification mechanism represents the process whereby an initial shock occurring within the financial sector triggers substantially larger shocks elsewhere in the sector and in the real economy. A number of other mechanisms have been proposed in the literature. Examples are the maturity mismatch between assets and liabilities (Diamond and Dybvig 1983), Knightian uncertainty (Krishnamurthy forthcoming; Pritsker 2010), and interdependency from credit chains, whereby firms simultaneously borrow and lend (Kiyotaki and Moore 1997b).

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Assessment Model for Systemic Institutions, or RAMSI (Aikman et al. 2009). In all of these cases, the initial trigger was relatively small in magnitude and local (for example, the Russian default in 1998 and news associated with mergers and acquisitions in 1987), but the crisis spread rapidly and globally to other markets. The amplification underlying these events is understood to operate as follows: an initial shock tightens funding constraints, causing the net worth of institutions to decrease and funding conditions to tighten further. We discuss the different ways proposed in the literature for funding shocks to reduce net worth, such as higher margins, lower collateral value, lower asset market prices, and higher volatility. Since the literature is extensive, we focus on a small number of key contributions that introduce alternative feedback loops between funding shocks and changes in net worth (or, more generally, balance-sheet conditions).

Central banks appear well placed to mitigate funding constraints as lenders of last resort (LOLRs). Since banks typically fund long-term assets with short-term money, a loss of confidence would force them to engage in asset "fire sales." By providing a liquidity backstop, central banks work to avoid potential fire sales. Bernanke (2009) describes the stages of the Federal Reserve's responses to the current crisis. The first-stage programs—the Term Auction Facility (TAF), central bank liquidity swaps, the Term Securities Lending Facility (TSLF), and the Primary Dealer Credit Facility (PDCF), all introduced between December 2007 and March 2008 (see exhibit)—involved the provision of short-term liquidity to sound financial institutions, in line with the Fed's traditional role of LOLR.[4]

We describe the Federal Reserve's first-stage liquidity programs and discuss available evidence on their effectiveness. The evidence is consistent with the view that the Fed mitigated funding stresses by charging lower effective rates on collateralized funds compared with rates in the private market. The Fed was able to take such action because, as a patient investor, it required a lower liquidity risk premium than private lenders did.

Next, we focus on the adverse-selection mechanism, which differs from the balance-sheet mechanism in terms of the role played by credit risk. The balance-sheet mechanism focuses on "collateralizable" net worth (Bernanke and Gertler 1989) and secured financing. Here, while credit risk may trigger the initial funding shock, it plays no role in the amplification mechanism. Clearly, though, in addition to this balance-sheet effect, feedback from asymmetric information and credit risk is also a potentially important amplifier in crisis periods. Indeed, as the crisis evolved, concerns about the credit risk of financial institutions and bank capital came increasingly to the fore.

Amplifications from adverse selection appear to be particularly relevant in the later stages of a crisis. We provide a brief survey of the literature that focuses mainly on those effects and their explicit policy implications, particularly for the current crisis. The literature finds that when borrowers have private information about their own asset values, private funding markets may break down, as safe borrowers exit the markets and lenders, faced with an adverse selection of risky borrowers, reduce their lending. The market failure provides a role for liquidity supply by central banks. However, the literature is also skeptical of the efficacy of such intervention in the face of asymmetric information.

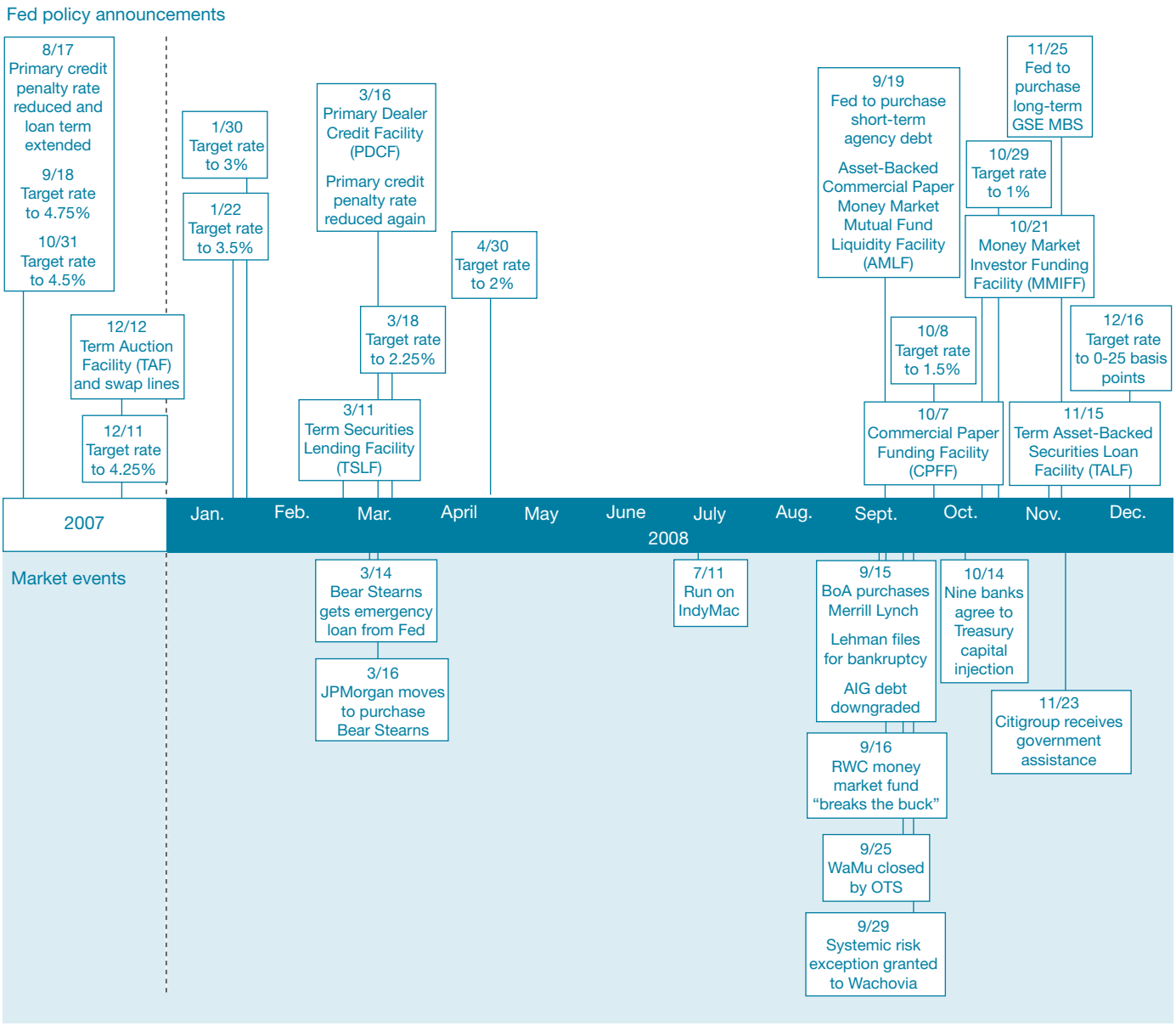
The Federal Reserve's crisis interventions evolved along with the changing nature of the crisis. The second-stage programs—the Asset-Backed Commercial Paper Money Market Mutual Fund Liquidity Facility (AMLF), the Commercial Paper Funding Facility (CPFF), the Money Market Investor Funding Facility (MMIFF), and the Term Asset-Backed Securities Loan Facility (TALF), all rolled out starting in September 2008 (see exhibit)—went beyond providing liquidity and addressed the funding needs of borrowers in selected credit markets. With these facilities, the Fed accepted a certain amount of credit risk, which it managed through the imposition of haircuts on the collateral given to it. The increased credit risk that the Fed accepted is attributable to the longer maturity of the loans (up to five years for TALF loans, for example), the nonrecourse nature of the loans in the case of the AMLF and TALF, and the broader set of counterparties (any U.S. company with eligible collateral can borrow at the TALF, for instance). Given the relatively late date of the introduction of these programs, examination of the programs and their effectiveness remains at an early stage.

Our study concludes by providing fresh evidence on the effect of changes in the Federal Reserve's supply of liquidity on changes in the three-month spread between the London interbank offered rate and the overnight indexed swap rate, better known as the Libor-OIS spread.[5] In contrast to previous work that focuses on announcement date effects, our paper examines changes in the amount outstanding of funds supplied by the Fed through the TAF and the swap facilities. We control for credit risk, the uncertainty regarding credit risk, and liquidity risk, guided by the literature. We distinguish between periods of increasing and decreasing supplies of funds by the Fed, and find that increases tend to reduce interest rates during

[4] We do not consider the Fed's term financing to JPMorgan Chase for the acquisition of Bear Stearns on March 14, 2008, to be a liquidity program, but rather a one-time transaction.

[5] Libor is a benchmark unsecured interbank interest rate published by the British Bankers' Association; OIS represents the expected average of the overnight fed funds rate over the term of the loan. The spread is widely used to measure interbank market stress.

Market Events and Federal Reserve Actions
December 2007-December 2008



periods of high funding liquidity risk. Surprisingly, decreases in the supply of funds also appear to be associated with lower spreads. Moreover, the impact of the funds supply on the spread has diminished over time, a result that is helpful in evaluating the impact of the Fed's potential future exit from its liquidity programs.

2. The Balance-Sheet Amplification Mechanism

The literature on balance-sheet mechanisms focuses on the principal agent problem between borrowers and lenders that arises from delegated investment. Households invest in hedge funds and mutual funds that invest in securities; these funds may in turn invest with more specialized investors with expertise in sophisticated trading strategies.[6] The principal

agent problem is defined as a deviation from first best outcomes associated with the necessity of external financing (Bernanke and Gertler 1989), and a consequence is that the intermediary's investments come to depend on external financing terms and the intermediary's balance-sheet conditions.

The balance-sheet amplification channel involves a positive feedback between funding constraints and changes in the asset values or cash flow of intermediaries. An early example is provided in Bernanke and Gertler (1989), who show how funding shocks reduce borrowers' cash flows and impair their ability to finance investments from retained earnings, thereby increasing the cost of new investments. They propose a model in which borrowers have better information about project quality than potential lenders do.[7] The resulting agency cost creates a wedge between the borrower's costs of internal and external funds. Moreover, the external funds premium is greater when borrower net worth is lower, as in periods of financial distress. This inverse relationship arises because agency costs are higher when borrower cash flows are lower and consequently the external funds premium must be greater to compensate the lender. Reduced investments result in lower output and cash flows, creating a "financial accelerator" effect of cash flows on investments attributable to countercyclical agency costs.

In literature subsequent to Bernanke and Gertler, emphasis is placed on the effect of funding shocks on asset prices (instead of cash flows), which affects firm net worth through changes in the value of assets and liabilities (Kiyotaki and Moore 1997a; Shleifer and Vishny 1997; Gromb and Vayanos 2002; Brunnermeier and Pedersen 2009). Since asset prices are forward looking, persistent shocks that impact them can have potentially large wealth effects.

The generic balance-sheet constraint for time t can be expressed (following Krishnamurthy [forthcoming]) as:

$$m_t \theta_t \leq w_t, \tag{1}$$

where m is broadly interpreted as a "margin" requirement per unit of asset holding, θ is the number of units of assets, and w is the value of equity capital. This interpretation of m is consistent with Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009).[8] In other words, the firm's equity capital must be sufficient to cover its total margins. Higher margins reduce asset prices, which in turn lower w and cause the constraint to tighten further; this is the feedback loop between funding conditions and asset market prices.

An alternative interpretation of m is obtained from Kiyotaki and Moore (1997a), in which lenders limit the debtor's investments based on pledged collateral. Suppose that borrowers pledge θ units of assets to borrow $\gamma\theta P$, where P is the asset price and $\gamma < 1$. Then, the borrower's budget constraint is:

$$\theta_t P_t \leq \gamma \theta_t P_t + w_t. \tag{2}$$

Or, rewriting,

$$(1 - \gamma) P_t \theta_t \leq w_t. \tag{3}$$

Here, γ can be viewed as the "haircut" on the collateral. If we write $m = (1 - \gamma)P$, then equations 3 and 1 are equivalent expressions of the budget constraint.

In Kiyotaki and Moore (1997a), credit constraints arise because borrowers can only borrow against assets that can be pledged as security for the loan. The pledgable assets have a dual capacity: as factors of production and as collateral. An initial productivity shock reduces the net worth of constrained firms, resulting in lower investments and lower prices of pledgable collateral assets. As asset prices fall, constrained firms suffer a capital loss on their collateral asset, and the magnitude of this loss is large because of leverage. The subsequent reduction in borrowing capacity leads to further rounds of decreased investments, asset prices, and borrower net worth.

While Bernanke and Gertler (1989) and Kiyotaki and Moore (1997a) are concerned with "collateralizable" net worth, they acknowledge but do not consider the market liquidity of the collateral. This issue is addressed by Shleifer and Vishny (1997), Gromb and Vayanos (2002), and Brunnermeier and Pedersen (2009). These papers are also concerned with the two-way feedback between borrowing limits and asset prices present in Kiyotaki and Moore. However, they also introduce the idea of a positive feedback between funding illiquidity and market illiquidity. Funding illiquidity is the marginal investor's scarcity value (or shadow cost) of capital; market illiquidity is the difference between the transaction price of a security and its fundamental value. The amplification mechanism discussed in these papers may be used to understand purely financial crises, independent of any effects on the real economy, such as the stock market crash of 1987 and the LTCM crisis of 1998.

Shleifer and Vishny (1997) examine the effect of intertemporal wealth constraints on the incentives of arbitrageurs to eliminate mispricings between two securities with identical cash flows. They consider the agency relationship

[6] For example, the "Fund of Funds" strategy is used by hedge funds that invest in other hedge funds.

[7] The superior information arises because the lender is assumed to pay a fixed auditing cost in order to observe the borrower's realized return, whereas the borrower observes a return for free.

[8] Margin constraints are perhaps the most common example of a balance-sheet constraint, but other constraints are possible. For example, in He and Krishnamurthy (2008), incentive conflicts limit the amount of coinvestment by outsiders in a mutual fund.

between arbitrageurs with specialized market knowledge, such as hedge funds, and the investors who fund them, such as wealthy individuals, banks, and endowments. If investors chase returns, they are likely to withdraw capital from arbitrageurs when prices are falling. In turn, arbitrageurs lacking capital are unable to reduce mispricing. This phenomenon is referred to as the "limits of arbitrage."

Gromb and Vayanos (2002) provide a welfare analysis of competitive arbitrage. In the process, they formalize many of the intuitions of Shleifer and Vishny (1997). The possibility of arbitrage arises because of segmented asset markets: some investors are able to invest in one risky asset but not in another (identical) risky asset. Arbitrageurs can invest in both assets and act as intermediaries: by exploiting price discrepancies, they facilitate trade among investors, effectively providing liquidity to them. Thus, arbitrage activity benefits all investors. It is assumed that arbitrageurs must have separate margin accounts for the two assets (that is, there is no cross-margining).[9] This implies that arbitrageur positions are wealth constrained. Gromb and Vayanos show that if changes in arbitrageur wealth are insufficient to cover variations in both margin accounts, arbitrageurs may be unable to take a position large enough to eliminate price discrepancies. Further, arbitrageurs may choose not to invest up to their wealth constraint if the capital gain from the arbitrage position is expected to be risky.[10] They can also increase price volatility by liquidating their positions in the event that price discrepancies widen further.

The feedback loop in Kiyotaki and Moore (1997a) and Gromb and Vayanos (2002) may be called an *illiquidity spiral*: reductions in collateral values result in lower asset prices and further reductions in collateral values. In terms of equation 3, the feedback is between θP and w, for given m. By comparison, Brunnermeier and Pedersen (2009) derive a *margin spiral,* in which lower asset prices reduce arbitrageur net worth through higher margins. In terms of equation 1, the feedback is between m and w, for given θ. While this distinction is useful for expositional reasons, changes in m and θ are clearly interdependent.

Brunnermeier and Pedersen examine the relationship between margin conditions and market illiquidity. In their model, customers with offsetting demand shocks arrive sequentially to the market. Speculators smooth the temporal order imbalance and thereby provide liquidity. The speculators borrow using collateral from financiers who set margins (defined as the difference between the security's price and its collateral value) to control their value-at-risk. Financiers can reset margins every period, so speculators face funding liquidity risk from the possibility of higher margins or losses on existing positions. A margin spiral occurs as follows: Suppose markets are initially highly illiquid and margins are increasing in market illiquidity.[11] A funding shock to speculators lowers market liquidity and results in higher margins, which cause speculators to delever, further tightening their funding constraints. Therefore, market liquidity falls even further.

There is no default risk in balance-sheet models, as loans are fully collateralized.[12] Thus, amplification works through fund flows and liquidity risk. The fact that inefficiencies can arise in the absence of credit risk suggests the positive role of central banks in alleviating funding and capital constraints during periods of crisis.

3. The Balance-Sheet Amplification Mechanism: Implications for Central Banks

The welfare analysis of Gromb and Vayanos (2002) shows that arbitrageurs may not take on an optimal level of risk, in part because they fail to internalize the effect on prices of changing their positions.[13] For example, arbitrageurs may underinvest in an arbitrage opportunity because they do not consider the possibility that larger positions in the current period would reduce price discrepancies in future periods. Thus, the key source of allocative inefficiency is the negative externality from changes in an arbitrageur's positions on other arbitrageurs.

[9] The authors argue that this assumption captures the notion that a custodian of the margin account in one market might refuse to accept a position in a different market as collateral. This assumption may not hold in all asset markets, however. For example, an arbitrageur with a simultaneous position in Treasury spot and futures markets generally cannot cross-margin.

[10] This follows from the possibility that the price discrepancy may grow wider and result in capital losses for arbitrageurs.

[11] This occurs if financiers are unsure if price changes are attributable to news shocks or liquidity shocks, and if volatility is time varying. Under these conditions, liquidity shocks lead to higher volatility, which increases financiers' expectations of future volatility; this in turn leads to higher margins. In contrast, if financiers know for sure that price changes are linked to fundamental news shocks, they realize that prices will revert in the future, making arbitrage positions in the current period profitable. This reduces the incentives of financiers to increase margins when liquidity decreases.

[12] This is explicit in Kiyotaki and Moore (1997a). Bernanke and Gertler (1989) explain that their model is about "collateralizable" net worth. The models of Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009) rule out default because margin accounts must be fully collateralized.

[13] An important reason why arbitrageur position changes are "Pareto-improving"—that is, they make some people better off without making anyone worse off—is that price changes result in wealth redistributions, and market segmentation implies that agents' marginal rates of substitution differ (as shown by Geanakoplos and Polemarchakis [1986] in a general, incomplete market setting). Arbitrageurs prefer to receive more wealth earlier while other investors prefer to receive wealth later; this creates the potential for Pareto-improving wealth redistributions across time and states.

An implication of Gromb and Vayanos is that regulatory intervention may affect arbitrageurs' financial constraints by reducing their capital and margin requirements or by providing financing to those institutions that provide capital to arbitrageurs.[14] Since the ex ante choice of leverage may be suboptimal, there is scope for prudential capital and liquidity requirements and, more generally, regulation of financial sector balance sheets. In addition, ex post policy actions to address the allocative inefficiency should be welfare improving, although they need not be unanimously approved (because of distributional effects).

In Bernanke and Gertler (1990), the optimal policy is a "debtor bailout," whereby the government redistributes endowment (via lump-sum taxes) from lenders to borrowers until the agency cost disappears. The policy works by directly addressing the problem of low net worth of borrowers (financial firms such as brokers, banks, and clearinghouses). Further, such transfers need not be direct, rather, they could be channeled through financial intermediaries under the assumptions that the latter can identify legitimate borrowers and that the government ensures that funds are channeled to successful projects. The moral-hazard problem is addressed by recommending bailouts only in response to large aggregate or systemic shocks over which borrowers have no control.

Brunnermeier and Pedersen (2009) discuss the ability of central banks to enhance market liquidity by controlling funding liquidity. If a central bank is effective at distinguishing news shocks and liquidity shocks and it conveys this distinction to financiers, the financiers may ease their margin requirements. Alternatively, the central bank can directly ease speculator funding conditions during a crisis, either by providing emergency funding at lower margins or simply by stating its intention to do so. If the statement is credible, financiers may loosen margin requirements, because their worst-case scenarios have a lower probability of occurring.[15]

[14] When regulators have limited control over financial constraints, they may prefer to tighten them in some cases to reduce overinvestment (for example, by limiting entry into the arbitrage industry). Overinvestment occurs if arbitrageurs are initially fully invested in the arbitrage opportunity. If demand by other investors increases, the price discrepancy widens and arbitrageurs suffer capital losses on their current positions. If arbitrageurs reduce their positions, they limit losses and can provide liquidity in future periods by trading more aggressively, a practice that mitigates the price wedge.

[15] Allen, Carletti, and Gale (2009) provide another rationale for central bank intervention. When markets are incomplete, the authors show that the price of the long-lived asset may exhibit excessive volatility. By using open market operations appropriately to set interest rates, the central bank can prevent the price volatility and implement the constrained efficient solution. Thus, the central bank effectively completes the market, and open market operations are sufficient to address systemic liquidity crises.

4. The Federal Reserve as Lender of Last Resort during the Early Stages of the Crisis

We turn to an assessment of the Federal Reserve's ex post interventions during the financial crisis, viewed in the context of the balance-sheet literature. From equations 1 and 3, we observe that a regulator has three types of instruments at its disposal:

- reducing m, the required margins on new funds;
- increasing γ, the value of pledgable assets;
- increasing w, the equity capital.

We focus on the Fed's efforts to reduce m and increase γ during the early stages of the crisis. Traditional LOLR policies advocate lending to solvent institutions against good collateral at a penalty rate (Rochet and Vives 2004). However, Cecchetti and Disyatat (2010) argue that, when there is generalized market failure, it may not make sense to provide liquidity at a penalty rate over the market rate because no institution benefits relative to others. The authors conclude that "liquidity support will often, and probably should, be provided at a subsidized [relative to the market] rate when it involves an illiquid asset in which a market price cannot be found."

Normally, the Fed provides reserves to a small number of primary dealers that distribute the funds to banks via interbank markets; in turn, banks lend to ultimate borrowers. When the markets are disrupted, the Fed relies on the discount window facility to provide short-term backup funding to eligible depository institutions. In the current crisis, interbank markets were dysfunctional, especially for term lending. The Fed encouraged banks to borrow from the discount window, but the banks were reluctant, perhaps in part because of the "stigma" associated with such borrowing.[16]

Responding to these concerns, the Fed introduced a number of programs (the aforementioned stage-one group) between December 2007 and March 2008 designed to provide short-term liquidity to sound financial institutions.[17] In the context of the balance-sheet literature, the programs can be viewed as easing balance-sheet constraints and thereby breaking the illiquidity spiral. An example is the TSLF, which allows dealers to exchange illiquid securities (say, MBS) for liquid Treasury securities that the dealers can subsequently use as collateral to

[16] For example, Furfine (2003) presents evidence consistent with potential borrowers staying away from the discount window, perhaps out of concern that such borrowing would be viewed as a sign of higher credit risk. Armantier et al. (2010) provide evidence that a discount window stigma existed throughout the financial crisis.

[17] See Armantier, Krieger, and McAndrews (2008), Adrian, Burke, and McAndrews (2009), and Fleming, Hrung, and Keane (2009) for descriptions of the TAF, PDCF, and TSLF programs, respectively. For descriptions of other Federal Reserve programs, see http://www.federalreserve.gov/monetarypolicy/bst.htm.

borrow funds. The dealer pays a smaller haircut (say, *H_Treasury*) when borrowing against liquid Treasuries than what it pays (say, *H_Illiquid*) when borrowing against illiquid securities. Of course, the TSLF also charges a haircut (say, *H_TSLF*). However, as long as *H_TSLF* < (*H_Illiquid* - *H_Treasury*), the facility lowers the dealer's net funding costs. Thus, the TSLF may be viewed as increasing γ in equation 3.

Other stage-one programs may be viewed as breaking the margin spiral (reducing *m* in equation 1). For example, the TAF auctioned credit to eligible depository institutions for a term of twenty-eight days initially and up to eighty-four days by August 2008. A similar program, the PDCF, issued credit to primary dealers. The international counterpart to TAF is bilateral currency swap arrangements with foreign central banks, which allow the banks to provide dollars to institutions in their own jurisdictions. These programs may bring down *m* in two ways: They may provide financing when private financing is simply unavailable, or when private financing is available only at more expensive terms.

How effective were these programs in reaching their objectives? To answer this question, we examine one liquidity risk proxy: the spread between overnight repo rates on MBS and Treasury securities.[18] Because both MBS and Treasury repo loans are collateralized and are issued for a short (overnight) maturity, the spread between them mainly reflects the relative illiquidity of the two assets. In particular, during the crisis, investors sought safety in the Treasury market while agency MBS became *relatively* illiquid, leading to an increase in the spread between agency MBS and Treasury repos.[19] The repo markets are important for bank financing (Hordahl and King 2008). In addition, if the secured financing market is stressed, it is highly likely that the unsecured financing market is also under duress. For these reasons, the MBS-Treasury repo spread provides a good proxy for funding illiquidity in the economy, not just in the secured financing markets.

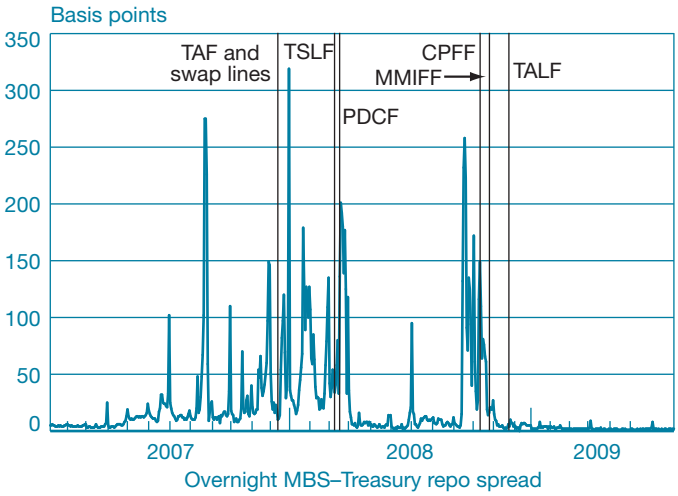
The source for the MBS-Treasury spread data is the Federal Reserve Bank of New York's primary dealer survey. The Trading Desk at the New York Fed collects information each morning from dealers on the average overnight general collateral repo rate at which each dealer has financed its positions in Treasury securities, agency debt securities, and agency MBS, as well as the quantity of securities financed. An overall weighted average is then calculated for each collateral type.

[18] Overnight repo rates on MBS are general collateral repo rates that reference nonspecific government securities with the lowest level of counterparty risk (Hordahl and King 2008). In contrast, specific collateral rates reference particular types of collateral, such as an on-the-run bond.

[19] Brunnermeier (2009) uses the repo spread (although not of the overnight maturity) to illustrate liquidity risk during the financial crisis. Gorton and Metrick (2009) discuss the role of repo markets during the crisis.

Chart 1

Liquidity Risk during the Financial Crisis



Sources: Federal Reserve Bank of New York; Haver Analytics.

Notes: MBS is mortgage-backed securities. Full names of the liquidity facilities appear in the exhibit on page 57.

Providing evidence on the effectiveness of the TSLF and PDCF programs, the spread between overnight agency MBS repo rates and Treasury collateral repo rates decreased after the TSLF program was implemented (Chart 1). Fleming, Hrung, and Keane (2009) show that this reduction is statistically significant. They further show that the narrowing of the repo spread is primarily attributable to increases in the Treasury repo rate and less so to decreases in the MBS repo rate. However, as the authors note, increases in the Treasury repo rate are important for the liquidity of the market.[20] Since the overnight repo spread may be attributable to the reduced collateral value (from lower market liquidity) of MBS relative to Treasuries, or to the increased collateral value of Treasuries (from higher market liquidity) relative to MBS, the reduction in the spread suggests an increase in γ.

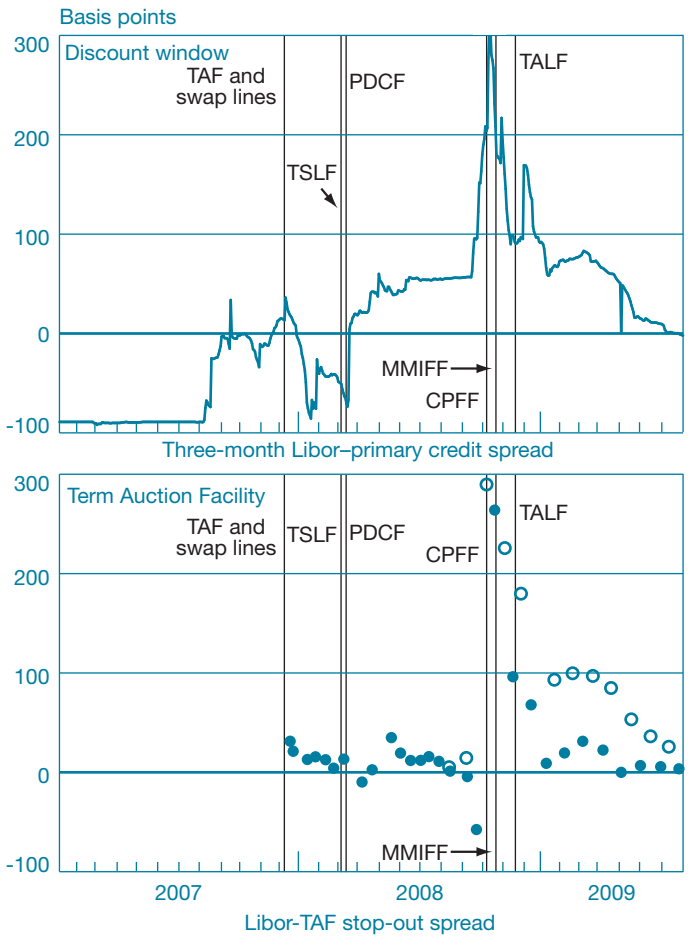
The top panel of Chart 2 shows the difference between the Libor, which is taken to be the benchmark borrowing rate in the private markets, and the discount window borrowing rate (the primary credit rate).[21] The discount window rate was

[20] Treasury securities are widely used as collateral for secured funding, so improved liquidity for Treasuries is likely to have a beneficial effect on secured funding rates in general. In addition, Fleming, Hrung, and Keane (2009) observe that an "unusually low Treasury general collateral repo rate puts downward pressure on repo rates for individual Treasury securities, increasing the likelihood of settlement problems" (also see Fleming and Garbade [2004, 2005]).

[21] The Libor is used for unsecured funding while the prime rate and the stop-out rate are used for secured funding. However, much of the collateral posted to the Fed was illiquid and could not be used to obtain secured funding elsewhere. Therefore, the Libor closely approximates the opportunity cost of funds for TAF participants.

Chart 2

Cost of Borrowing from the Federal Reserve Relative to the Market



Sources: Federal Reserve Bank of New York; Haver Analytics; British Bankers' Association; Bloomberg.

Notes: Libor is the London interbank offered rate. Solid circles represent the one-month Libor–twenty-eight-day TAF stop-out spread; open circles represent the three-month Libor–eighty-four-day TAF stop-out spread. For twenty-eight-day TAF auctions, the Libor-TAF spread is calculated as the spread between the one-month Libor and the twenty-eight-day TAF; for eighty-four-day TAF auctions, the spread is calculated as the spread between the three-month Libor and the eighty-four-day TAF. Full names of the liquidity facilities appear in the exhibit on page 57.

initially above the Libor, a development that partly explains banks' reluctance to use the window early in the crisis. The bottom panel of the chart illustrates the difference between the Libor and stop-out rates in the twenty-eight- and eighty-four-day TAF auctions. It shows that the Libor generally exceeded the stop-out rates, indicating that the Fed was successful in providing credit at below-market rates. In addition, evidence indicates that the TAF and the swap line programs reduced interest rate spreads.[22]

The Federal Reserve's success in easing funding constraints during the crisis likely had a beneficial effect on the real economy, via the channels suggested in Bernanke and Gertler (1989) and Kiyotaki and Moore (1997a). Del Negro et al. (2009), who extend the model of Kiyotaki and Moore (2008), study the impact of a large shock of the order of magnitude observed in the 2008 financial crisis. Their model simulations suggest that the Fed's policy interventions in 2008-09 prevented a repeat of the Great Depression.

5. The Adverse-Selection Amplification Mechanism: Implications for Central Banks

The Federal Reserve's first-stage liquidity programs exposed it to minimal credit risk. The Fed's loans to banks and primary dealers through the various facilities are overcollateralized and made with recourse to the borrowing firm.[23] In the case of the currency swap lines, the foreign central banks are responsible for payments; moreover, the Fed receives and holds an equivalent amount of foreign exchange for the dollars it provides to the central banks.

As the crisis evolved, concerns about the credit risk of financial institutions and bank capital came increasingly to the fore. The Fed's stage-one programs were dependent on solvent institutions to intermediate credit flow from the central bank to the economy.[24] As these intermediaries themselves became impaired, they were less willing to lend. In addition, certain credit markets, such as commercial paper, were particularly afflicted. Consequently, the Fed decided to lend directly to some affected borrowers and markets. Thus, with its second-stage programs, the Fed was forced to take on and manage a certain amount of credit risk.

To understand the intent behind these programs, we examine amplification mechanisms based on asymmetric information between borrowers and lenders. In contrast to our

[22] McAndrews, Sarkar, and Wang (2008) study the effect of the TAF on the Libor-OIS spread. McAndrews (2009) and Coffey, Hrung, and Sarkar (2009) analyze the effect of swap lines: the former on the Libor–fed funds spread, the latter on deviations from covered interest rate parity. Cetorelli and Goldberg (2009) examine the effect of liquidity programs on the internal capital markets of global banks.

[23] For a description of the required collateral, see http://www.federalreserve.gov/monetarypolicy/bst_ratesetting.htm.

[24] The Federal Reserve's objective was to improve the distribution of liquidity across financial intermediaries, as stated in its announcement of the TAF program on December 12, 2007 (http://www.federalreserve.gov/newsevents/press/monetary/20071212a.htm). This objective could not have been achieved by way of a generalized injection of liquidity, such as through the purchase of Treasury debt.

review of balance-sheet amplifiers, we focus here on the role of credit risk and the distribution of credit risk across borrowers. The papers surveyed in this discussion find a role for central bank intervention when adverse-selection problems lead to market breakdowns. However, they also raise concerns that central bank liquidity provision might crowd out private market liquidity.

Heider, Hoerova, and Holthausen (2009) build a model of the effect of counterparty risk on unsecured interbank markets with asymmetric information.[25] Banks need liquidity, as customers may withdraw deposits on demand (as in Diamond and Dybvig [1983]). The interbank markets distribute funding from banks with excess reserve balances to those with reserve shortages. Counterparty risk exists because banks have risky long-term assets and may be unable to repay their interbank loans. Asymmetric information about counterparty risk exists because banks have private information about the riskiness of their long-term assets.

The authors show that different regimes occur in the interbank markets depending on the level and distribution of counterparty risk. Because lenders cannot distinguish between safe and risky banks, the interest rate contains a risk premium. In the "good" regime, the risk premium is small compared with the opportunity cost of funds, so the interbank markets perform smoothly with low interest rates. If, however, the risk premium is too high, safe borrowers exit the interbank markets. Consequently, in this "worst" regime, lenders face an adverse selection of risky borrowers and the interest rate is high. In this regime, both the level and the dispersion of credit risk are high;[26] as a result, the interbank markets stop functioning. Either lenders find it unprofitable to lend (even at high interest rates) and thus hoard funds,[27] or risky borrowers find the interest rate too high and exit.

What are the implications of this model for central bank liquidity supply? [28] Suppose credit risk increases unexpectedly and lenders face an adverse selection of borrowers (but the market is still functioning). If the central bank has the same information as the market, it can offer liquidity to all banks at the highest interest rate that safe banks are willing to accept. As in Flannery (1996), this rate is discounted relative to the market rate, and the central bank's supply of liquidity mitigates the private liquidity shortage. The cost is that the central bank does not distinguish between sound and risky institutions, a concern also raised by Goodfriend and King (1988). Moreover, the private supply of liquidity is crowded out.

Bolton, Santos, and Scheinkman (2009) also raise the possibility that central bank liquidity crowds out private liquidity.[29] Their model features two types of investors: short-run investors, who invest in valuable risky projects that typically mature early, and long-run investors, who invest in higher return long-term assets. The ex ante efficient solution is for short-run investors to sell risky assets to long-run investors (to obtain "outside" liquidity) and for trading not to occur too quickly. However, short-run investors have private information about the assets. If investors are concerned about adverse-selection problems that may undermine secondary markets in the future, they may trade too soon and at fire-sale prices.

A central bank may step in and provide liquidity (in the form of price support) to mitigate the fire sale. The effectiveness of liquidity supply depends on whether the central bank can accurately time the supply. If it delays liquidity provision, it crowds out outside liquidity and undermines the incentives of short-run investors to obtain outside liquidity by selling assets for cash. However, if the central bank acts quickly, its liquidity can complement private market liquidity. In this case, the central bank plays the role of market maker of last resort by inducing short-run investors to obtain liquidity through asset sales.

[25] Flannery (1996) also studies asymmetric information problems and identifies a "winner's curse" facing new lenders in banking markets. He shows that private loan markets can fail because lenders become less certain about how to distinguish between illiquid and insolvent banks.

[26] If $p_s(p_r)$ is the probability that the long-term investment has a higher-(lower-) than-expected chance of success, dispersion is defined as $p_s - p_r$.

[27] Liquidity hoarding can also arise if banks fear that they will be unable to finance projects and trading strategies because of uncertainty in the aggregate demand for liquidity (Allen, Carletti, and Gale 2009). In such a case, central bank intervention may not be needed because banks hold sufficient liquidity to meet their own needs without accessing the interbank markets (Allen and Carletti 2008).

[28] There is a vast literature on central bank or government intervention to address market failures in the face of asymmetric information, moral hazard, and monopoly power. Holmstrom and Tirole (1998) and Diamond and Rajan (2005) analyze the optimal (central bank) provision of liquidity when interbank markets face aggregate liquidity shocks and contagious failures generated by the illiquidity of bank assets. Gorton and Huang (2006) rationalize the LOLR function of central banks with the need to monitor banks and provide them with liquidity during crises in order to prevent inefficient panics. Acharya, Gromb, and Yorulmazer (2008) examine how the strategic power of an interbank lender might force a liquidity-constrained borrower to sell at fire-sale prices. The strategic power is the market failure that justifies central bank intervention.

[29] Bolton, Santos, and Scheinkman (2009) build on the literature that integrates financial intermediaries and securities markets in a single framework. In Diamond (1997), banks coexist with securities markets because households face costs associated with switching between banks and securities markets. Fecht (2004) introduces segmentation on the asset side between financial intermediaries' investments in firms and claims issued directly by firms to investors through securities markets. Allen and Gale (2004) introduce securities markets into a general-equilibrium theory of institutions. Intermediaries provide liquidity insurance, as in Diamond and Dybvig (1983), and risk-sharing services by packaging existing claims for investors that lack access to markets. The financial system is efficient as long as markets are complete.

6. Adverse Selection and the Fed's Actions during the Later Stages of the Crisis

The Fed's second-stage programs were designed to provide funding in a targeted manner to borrowers and investors in key credit markets (Bernanke 2009). These programs, rolled out starting in September 2008, came in two varieties (see exhibit). Continuing its LOLR role, the Federal Reserve provided a liquidity backstop to money market mutual funds and to commercial paper borrowers. The Fed developed a facility to finance bank purchases of high-grade asset-backed commercial paper from money market mutual funds, which helped the funds to meet redemption demands without having to sell assets at distress prices. Through another facility, the Fed bought high-quality (A1-P1) commercial paper at a term of three months, which reduced the risk of commercial paper borrowers being unable to roll over maturing issues.

The second type of Federal Reserve programs went beyond providing liquidity to address the funding needs of borrowers in selected asset-backed markets. The TALF, representing a joint effort with the U.S. Treasury, provides three- or five-year term loans to investors against (mostly) new issuances of AAA-rated securities. With the Treasury providing funding, the facility allows the Fed to accept a certain amount of credit risk. The Fed manages the credit risk through the imposition of haircuts on the collateral put to it. The objective of the program is to revive private lending by enabling lenders to securitize new loans. In addition, by stimulating market activity, the facility potentially increases the valuation of existing loans by reducing the illiquidity premium.

The design of the TALF program appears to address the concern that the Fed might crowd out the private supply of liquidity in the affected markets. The program leverages private originations of asset-backed securities, consistent with Bolton, Santos, Scheinkman (2009). Further, it offers funding at different rates for various asset classes (as the haircuts differ by asset). This feature appears to alleviate the moral-hazard problems inherent in offering a flat rate to all investors independent of credit risk, a concern raised by Goodfriend and King (1988) and Heider, Hoerova, and Holthausen (2009).

Given the relative newness of these programs, rigorous empirical evidence on their effectiveness is scarce. An exception is Ashcraft, Garleanu, and Pedersen (2009), who report the results of a survey of financial institutions on how the institutions' bid prices for securities depend on Federal Reserve financing. The Fed, by offering loans at lower margins than the market, effectively lowers the required return for holding securities put to the TALF. Consistent with this idea, the surveyed bid price increases as the Fed reduces its offered margins. This evidence is consistent with the expected effect of lower margins on asset prices.

7. Evolution of Credit and Liquidity Risk during the Crisis

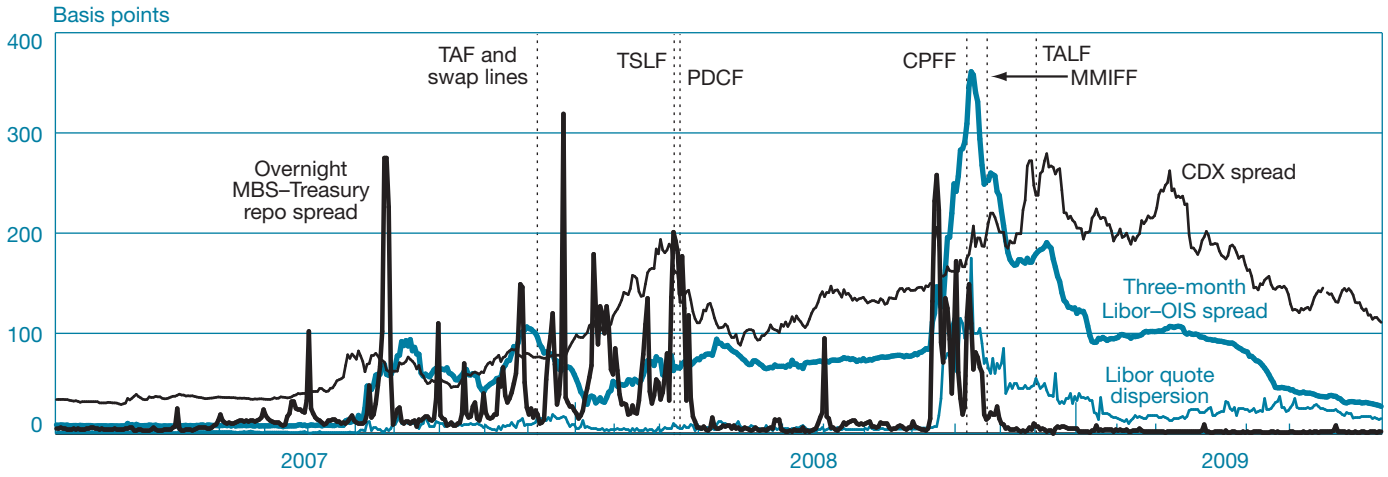
As the crisis progressed, the relative importance of the balance-sheet and adverse-selection mechanisms likely changed. This evolution is implicit in the timing of the Fed's responses. In particular, the Fed's stage-one programs emphasized the provision of liquidity to solvent institutions, suggesting that at this early point in the crisis the Fed viewed a lack of access to funding as a greater risk to the economy than counterparty credit risk. In contrast, the second-stage programs reflected the Fed's views on the increasing importance of credit risk. In this section, we estimate proxies for liquidity risk, credit risk, and the distribution of credit risk across banks to examine the changing importance of the financial amplification mechanisms over time.

The adverse-selection effects operate via credit risk and its distribution across banks (Heider, Hoerova, and Holthausen 2009). The credit risk measures considered here are the CDX IG index of credit default swap (CDS) spreads and the dispersion in Libor panel quotes. The CDX IG index, provided by Markit, is composed of spreads on five-year CDS contracts for 125 North American companies; it provides information on the average default risk of major global firms. Because the index tends to rise with increases in the level of economy-wide credit risk, we expect a positive relationship between the index and adverse selection.

The Libor panel dispersion, provided by the British Bankers' Association via Bloomberg, is defined as the difference between the maximum and minimum three-month quote of the sixteen Libor panel banks each day; it proxies for uncertainty about counterparty credit risk. The quote dispersion shows the extent to which some Libor panel banks report greater borrowing costs, an indicator of higher counterparty risk compared with the typical Libor panel bank. Our uncertainty measure is consistent with those proposed in Heider, Hoerova, Holthausen (2009) and Pritsker (2010), that is, the spread in default probabilities assigned by lenders to a borrower's investments. Again, the expected relationship between the quote dispersion and adverse selection is positive.

Balance-sheet effects operate according to illiquidity and margin conditions. To measure liquidity risk, we use the spread overnight MBS and Treasury general collateral repo rates. As discussed in Section 4, the spread between these two rates should primarily reflect the relative illiquidity of MBS relative

Chart 3
Risk Evolution during the Crisis



Sources: Federal Reserve Bank of New York; Haver Analytics, Markit; British Bankers' Association.

Notes: MBS is mortgage-backed securities; Libor is the London interbank offered rate. The overnight MBS–Treasury repo spread is the liquidity risk proxy; the CDX spread and the Libor quote dispersion are the credit risk proxies. Full names of the liquidity facilities appear in the exhibit on page 57.

to Treasuries. The credit risk component of these two rates is minimal because of the secured nature of the transaction, the short duration of the loan, and haircuts that are generally set in advance. In contrast, the daily repo rate on a given day reflects supply and demand pressures in the market. During the financial crisis, there was a rush to buy Treasuries, which increased the demand for these securities. The greater demand likely lowered the risk of a repo buyer being unable to sell the Treasuries in the event of counterparty default. Impairment in the MBS market, however, meant that the same was not true for buyers accepting MBS securities as collateral. Therefore, the differences in these two rates reflect the ability of buyers to quickly and easily sell the collateral from their repo transactions—in other words, the two securities are relatively liquid. We compare these series to the three-month Libor-OIS spread, which contains credit and noncredit risk premia. Arbitrage should normally ensure that the spread is close to zero, but the spread has widened dramatically during the crisis (Chart 2).[30] The variable considered here takes Libor quotes reported on day t+1 and the OIS rate reported on date t, both at a term of three months. We use t+1 Libor rates because the rate is fixed each morning at 11:00 a.m. London time while the OIS rate is determined at the end of the business day, U.S. Eastern time.

Chart 3 illustrates the evolution of liquidity risk (the MBS-Treasury repo spread) and credit risk (the CDX IG index and Libor quote dispersion) during the crisis, along with the Libor-OIS spread. All values are in basis points. The evolution of risk proxies is consistent with the view that, at the beginning of the crisis, liquidity risk was relatively more important than credit risk, but credit risk became more prominent as the crisis progressed, gaining particular importance after April 2008 and especially during September 2008. The initial months of the crisis were characterized by large spikes in liquidity risk, but only a modest rise in credit risk. After April 2008, however, liquidity risk fell while the CDX spread remained elevated. After mid-September 2008, both types of risk increased, but the two credit risk proxies increased relatively more and remained elevated longer.

The Libor-OIS spread appears to co-move with both the credit and liquidity risk variables during the crisis period. We examine changes in the spread more formally in the next section.

[30] The arbitrage works as follows: loan $X for, say, three months, fund the loan by borrowing $X each day in the fed funds market and, finally, hedge the interest rate risk by purchasing an OIS contract (Gorton and Metrick 2009).

8. Effectiveness of the Fed's Liquidity Supply: Methodology

Here, we investigate the relationship between the Libor-OIS spread and the supply of funds through the Federal Reserve's TAF and swap facilities. We focus on the latter facilities because they are the longest running new programs introduced during the crisis, and because both were meant to provide dollar funding to the interbank markets (in contrast to other stage-one liquidity programs, such as the TSLF).

We interpret the TAF and swap programs as primarily intending to decrease liquidity risk. Because the Libor-OIS spread contains credit and noncredit risk components, we control for credit risk to obtain meaningful correlations between the spread and the supply of funds by the Fed. To isolate the supply effects, we consider changes in the amount of funds outstanding, which are the net effect of changes in the Fed's supply of funds and repayment of funds by participating banks. During the first ten months of TAF operation, the Fed raised the maximum amount offered at auction four times, introduced longer term auctions, and increased the frequency of auctions. The swap facility underwent similar changes, such as increases in size and adjustments in frequency. These changes worked mainly to increase the size of the programs; more recently, the Fed has been reducing their size.

Our maintained assumption is that changes in the TAF and in the swap amount outstanding are exogenous. Before October 2008, the Fed and other central banks determined the maximum offering amount for the TAF and the swap lines well in advance of the auctions, and banks fully subscribed to each auction. Thus, changes in the amount outstanding for these facilities were not influenced by market conditions concurrent with the supply announcement dates. Although the offer amounts were known in advance, uncertainty remained about whether the auctions would be fully subscribed; therefore, changes in the amount outstanding were not fully anticipated by banks. We calculate changes in the amount outstanding to occur on the day of disclosure rather than on the date of funds disbursement (generally two days later) to maximize the "news" content of our measure.

Since October 2008, the TAF offer amount was increased to $150 billion per auction and the auctions became undersubscribed. At almost the same time, the swap lines were uncapped and foreign banks were allowed to bid for any quantity of funds. These changes meant that market conditions around auction dates likely played a larger role in determining the actual amount of funds disbursed. For this reason, endogeneity problems are likely to be greater since October 2008. To mitigate this concern, we include the Treasury-MBS general collateral repo spread to help control for changes in bank demand for TAF and swap loans.

McAndrews, Sarkar, and Wang (2008) decompose the Libor-OIS spread into its credit risk and non–credit-risk components for the January 2007-April 2008 period. They find that the non–credit-risk component was the major part of the spread in 2007. The credit risk component was high and volatile in 2008. However, because the CDS market became highly illiquid at this time, part of the credit risk component is likely to reflect liquidity risk as well. Consistent with the importance of liquidity risk, the authors find that the Fed's announcements of new supplies of TAF funds significantly reduced the Libor-OIS spread during their sample period.

Our analysis differs from that study's approach in four primary respects. First, we use changes in the actual *supply* of funds through the TAF and swap facilities rather than announcement dates. The amount outstanding variable, being continuous, is able to capture variations in supply changes, unlike the auction date variables used by McAndrews, Sarkar, and Wang, which are binary. Second, our examination of a longer time series enables us to analyze recent decreases in the size of these facilities, potentially allowing us to draw implications for the Fed's exit strategies. Third, we look at the TAF and swap facilities simultaneously, a natural approach because of the facilities' high degree of similarity. Both are intended to provide dollar funding to a broad range of counterparties, both were introduced at the same time and relatively early in the crisis, and both correspond closely in terms of the timing, terms, and magnitude of auctions. Finally, we employ an expanded set of covariates to control for credit and liquidity risk.

We examine interactions between binary variables over four periods and the TAF and swap amounts outstanding to allow for changes in the importance of liquidity risk over time.[31] The periods are chosen to correspond to the turning points of the crisis and to encompass TAF and swap auctions that occurred around these points. Period 1 starts on August 1, 2007, roughly the beginning of the crisis, and ends on March 9, 2008. Period 2 begins on March 10, 2008, the date of the last TAF auction before the acquisition of Bear Stearns by JPMorgan Chase, and ends on September 9, 2008. Period 3 captures the Lehman bankruptcy and its aftermath, beginning on September 10, 2008, and ending on December 31, 2008. The final period runs from January 1, 2009, through July 31, 2009, a period when markets were normalizing.

[31] The effect of risk variables on the Libor-OIS spread could also change over time. Unreported results from regressions allowing the risk variable coefficients to vary over different crisis periods indicate no qualitative changes to our estimates for the amounts outstanding of the TAF and swap variables.

Table 1

Variables Used in Regressions

Variable	Description	Unit
Three-month Libor-OIS spread on date *t*	Three-month Libor on date *t*+1 minus three-month OIS rate on date *t*	Basis points
TAF outstanding	Outstanding value of TAF funds on award announcement date	Billions of U.S. dollars
Non-negative component of TAF outstanding	Equal to the maximum of TAF outstanding and 0	Billions of U.S. dollars
Non-positive component of TAF outstanding	Minimum of 0 and TAF outstanding	Billions of U.S. dollars
Swap outstanding	Outstanding value of all swap lines on award announcement date	Billions of U.S. dollars
Non-negative component of swap outstanding	Maximum of swap outstanding and 0	Billions of U.S. dollars
Non-positive component of swap outstanding	Minimum of 0 and swap outstanding	Billions of U.S. dollars
Period 1	Binary variable equal to 1 for dates between August 1, 2007, and March 9, 2008; 0 otherwise	—
Period 2	Binary variable equal to 1 for dates between March 10, 2008, and September 9, 2008; 0 otherwise	—
Period 3	Binary variable equal to 1 for dates between September 10, 2008, and December 31, 2008; 0 otherwise	—
Period 4	Binary variable equal to 1 for dates between January 2, 2009, and July 31, 2009; 0 otherwise	—
CDX spread	CDX IG index	Basis points
Three-month Libor quote dispersion on date *t*	Difference between maximum and minimum quote of banks in three-month Libor panel on date *t*+1	Basis points
VIX	Options-implied volatility in equities market	Basis points
Overnight MBS–Treasury spread	Overnight MBS rate minus Treasury general collateral repo rate	Basis points

Note: Libor is the London interbank offered rate; TAF is the Term Auction Facility; MBS is mortgage-backed securities.

We estimate the following equation, where Δ is the daily change in the variable:

$$
\begin{aligned}
(4)\ \Delta(Libor-OIS_t) = {} & \beta_1 + \beta_2 \Delta TAF_t * Period1 \\
& + \beta_3 \Delta TAF_t * Period2 + \beta_4 \Delta TAF_t * Period3 \\
& + \beta_5 \Delta TAF_t * Period4 \\
& + \beta_6 \Delta SWAP_t * Period1 \\
& + \beta_7 \Delta SWAP_t * Period2 \\
& + \beta_8 \Delta SWAP_t * Period3 \\
& + \beta_9 \Delta SWAP_t * Period4 \\
& + \beta_{10} \Delta CDX_t + \beta_{11} \Delta LIBOR\_DISP_t \\
& + \beta_{12} \Delta VIX_t + \beta_{13} \Delta MBS - TRSY\_REPO_t \\
& + \varepsilon_t .
\end{aligned}
$$

The equation relates changes in the Libor-OIS spread to changes in the amounts outstanding at the Fed's TAF (denoted ΔTAF) and swap (denoted $\Delta SWAP$) facilities. We control for credit risk using the CDX index (ΔCDX) and the Libor quote dispersion variable ($\Delta LIBOR\_DISP$). We control for general market risk using options-implied volatility in the equity market (ΔVIX). Because VIX has been found to be a significant determinant of asset prices in several markets, we use it to account for financial market risk broadly.[32] Finally, we control for banks' balance-sheet funding risk using the overnight MBS-Treasury repo spread ($\Delta MBS - TRSY\_REPO$). We use changes in variables to account for deterministic time-series effects, such as trends. All variables are summarized in Table 1. TAF auction results are from the Federal Reserve Board website; swap line results are from participating central bank websites.[33] VIX data are from Bloomberg.

In a related regression, we decompose the TAF and swap line amounts outstanding into positive and negative changes. To be specific, we replace ΔTAF in equation 4 with the following terms:

$$\Delta TAFP = max.(0, \Delta TAF) \text{ and } \Delta TAFN = min.(0, \Delta TAF).$$

[32] VIX has been shown to be a significant determinant of prices of foreign exchange (Brunnermeier, Nagel, and Pedersen 2008) and sovereign CDS (Longstaff et al. 2007).

Further, we replace $\Delta SWAP$ in equation 4 with the following terms:

$\Delta SWAPP = max.(0, \Delta SWAP)$, and
$\Delta SWAPN = min.(0, \Delta SWAP)$.

The balance-sheet constraint is predicted to bind on the down side (when intermediaries are capital constrained) but not on the up side (when capital is widely available). This predicted asymmetry implies that increases in the supply of funds by the Fed should decrease spreads, whereas reductions in the supply should have little impact on them.

9. The Effectiveness of the Fed's Liquidity Supply: Results

Table 2 presents our results from estimating equation 4. The results indicate that the supply of funds from both the TAF and the swap line programs was associated with a reduction in the Libor-OIS spread during the early phase of the crisis (up to March 9, 2008). In particular, an increase of $1 billion in the supply of TAF and swap line funds outstanding is associated with an average decline in the spread of 0.1 to 0.5 basis point during this period. This result is consistent with the operation of the balance-sheet amplification mechanism in the early stage of the crisis.

We find that in subsequent periods, the supply of TAF and swap funds is not a significant predictor of the interest rate spread. The sign of the TAF supply coefficient remains negative in Periods 2 and 3, but it is not significant.[34] In the next section, we show that this apparent lack of significance may be attributable to an averaging of the separate effects of increases and decreases in the supply of funds. The sign of the swap line coefficient is negative in Periods 1 and 3. Overall, considering

[33] http://www.federalreserve.gov/monetarypolicy/taf.htm
http://www.ecb.int/mopo/implement/omo/html/index.en.html
http://www.snb.ch/en/ifor/finmkt/id/finmkt_usdollars?LIST=lid1&EXPAND=lid1&START=1
http://www.bankofengland.co.uk/markets/other/dollarrepo/index.htm
http://www.boj.or.jp/en/type/release/adhoc/mok0812b.pdf
http://www.rba.gov.au/MarketOperations/Domestic/ExcelFiles/usd_repos.xls
http://www.riksbank.com/templates/ItemList.aspx?id=30117
http://www.norges-bank.no/templates/pagelisting____73626.aspx
http://www.nationalbanken.dk/DNUK/MarketInfo.nsf/side USD_auction!OpenDocument
http://www.bok.or.kr/broadcast.action?menuNaviId=1562
http://www.banxico.org.mx/sitioingles/portalesEspecializados/tiposCambio US_dollar_auctions_results.html

[34] The difference between the TAF coefficient in the early crisis period (Period 1) and Period 2 is not statistically significant, but the Period 1 coefficient is significantly different from the estimates for Periods 3 and 4. The early crisis swap coefficient is significantly different from all later swap coefficients.

Table 2
Changes in Amounts Outstanding at Federal Reserve Facilities, and the Libor-OIS Spread
August 2007-July 2009

Dependent Variable: Change in Three-Month Libor-OIS Spread

Explanatory Variable	Coefficient
Change in TAF outstanding	
Period 1: August 1, 2007–March 9, 2008	-0.130***
	(0.037)
Period 2: March 10, 2008–September 9, 2008	-0.167
	(0.110)
Period 3: September 10, 2008–December 31, 2008	-0.031
	(0.036)
Period 4: January 2, 2009–July 31, 2009	0.009
	(0.018)
Change in swap outstanding	
Period 1: August 1, 2007–March 9, 2008	-0.481***
	(0.150)
Period 2: March 10, 2008–September 9, 2008	0.048
	(0.065)
Period 3: September 10, 2008–December 31, 2008	-0.047
	(0.064)
Period 4: January 2, 2009–July 31, 2009	0.019
	(0.016)
Credit risk	
Change in CDX spread	0.140***
	(0.042)
Change in three-month Libor quote dispersion	0.160***
	(0.050)
Liquidity risk	
Change in overnight MBS–Treasury spread	0.025*
	(0.014)
Market risk	
Change in VIX	0.511***
	(0.139)
Constant	0.091
	(0.286)
Adjusted R^2	0.17
Observations	607

Source: Authors' calculations, based on data from the British Bankers' Association, Haver Analytics, the Board of Governors of the Federal Reserve System, foreign central banks, the Federal Reserve Bank of New York, and Markit.

Notes: Newey-West standard errors (five lags) are in parentheses. The full sample is daily observations from January 3, 2007, to July 31, 2009. TAF is the Term Auction Facility. See Table 1 for a description of variables.
*** p<0.01.
** p<0.05.
* p<0.1.

the TAF and swap line results together, we conclude that the supply of liquidity by the Fed was most effective in the early stages of the crisis and the effectiveness moderated over time.

The credit risk variables are of the expected sign, with the Libor quote dispersion and the CDX spread being positively and significantly associated with the Libor-OIS spread. A 1 basis point change in either credit risk variable is associated with about a 0.15 basis point change in the Libor-OIS spread.[35] The overnight repo spread is also positively associated with the Libor-OIS spread during the crisis, but the estimate is only significant at the 10 percent level. As we discussed, the marginal significance of the repo spread might be explained by the Fed's action to reduce the spread through the PDCF and TSLF programs. Finally, changes in VIX are also significantly and positively associated with the Libor-OIS spread.[36]

Results from the regressions provide an indication of when the Fed might expect its liquidity facilities to help improve funding conditions. Comparing the coefficient estimates with the results in Chart 3, we observe that the facilities were most effective during periods of high liquidity risk and relatively low credit risk. The facilities did not appear to be effective during periods of extremely elevated credit risk, such as the months just after the Lehman failure in 2008, and during periods of low liquidity risk, such as the first half of 2009. This is consistent with the stated intentions of the TAF and swap facilities: to provide short-term funding to banks. As such, these facilities were not expected to have a direct effect on the credit risk of banks.

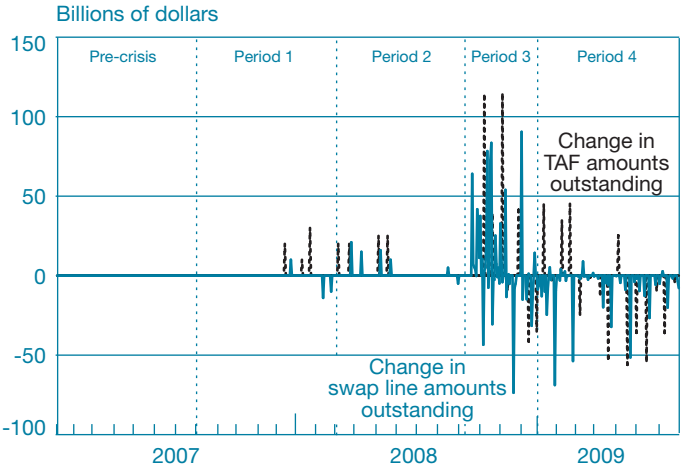
10. Asymmetric Market Responses to the Fed's Liquidity Supply

We next report estimates using TAF and swap outstanding variables decomposed into positive and negative changes. Chart 4 presents the time-series plots of the two main variables of interest: changes in TAF and swap amounts outstanding. Note that the TAF has experienced negative changes in amounts outstanding since Period 3, while the swap lines have experienced both increases and decreases during each period since the crisis began. The share of negative changes in the TAF and swap lines combined, compared with the total number of changes, is small in Periods 1 and 2, and rises to 40 percent in Period 3 and 80 percent in Period 4.

[35] Similar specifications with indexes of Libor bank CDS spreads instead of the CDX index yielded highly similar results for the TAF and swap variables of interest, but results for the Libor-based indexes were insignificant.

[36] We also considered the term premium, defined as the spread between the five- and two-year on-the-run Treasury yields, but this variable was not a significant predictor of the Libor-OIS spread.

Chart 4
Changes in Term Auction Facility (TAF) and Swap Line Amounts Outstanding



Sources: Federal Reserve Bank of New York; foreign central banks.

Note: Vertical lines correspond to the period divisions used in the estimations.

The results from estimation of the second regression are presented in Table 3. *Symmetric* responses of the Libor-OIS spread are indicated by negative changes to both increases and decreases in the amount outstanding—that is, reductions (increases) in the spread in response to a decrease (increase) in the amount outstanding. By comparison, *asymmetric* responses are indicated by different signs of the coefficient depending on whether the change in amount outstanding is positive or negative.

In the pre–Bear Stearns period (Period 1), expansion of the TAF and swap lines in the early part of the crisis tended to be associated with a reduction in the Libor-OIS spread, consistent with prior results. Further, reductions in the swap line amount outstanding resulted in an increase in the spread. Therefore, the effect of the Fed's funds supply is symmetric during this period.

In contrast, during the post–Lehman periods (Periods 3 and 4), the effect of liquidity supply by the Fed is asymmetric. In particular, decreases in the TAF and swap amounts outstanding are associated with declines in the Libor-OIS spread, whereas increases in the TAF and swap lines are also associated with decreases in the spread during this period. These results are statistically significant for changes in the TAF amount outstanding. This asymmetry suggests that the lack of significance in the overall TAF coefficients during Periods 3 and 4 in Table 2 may be attributable to an averaging of the positive and negative changes (which are of roughly equal magnitude). Hence, to understand responses of interest rates to changes in the supply of funds by the Fed during the post–Lehman period, it is important to account for this asymmetry.

Table 3

Positive and Negative Changes in Amounts Outstanding at Federal Reserve Facilities

August 2007-July 2009

Dependent Variable: Change in Three-Month Libor-OIS Spread	
Explanatory Variable	Coefficient
Positive changes in TAF outstanding	
Period 1: August 1, 2007–March 9, 2008	-0.093**
	(0.045)
Period 2: March 10, 2008–September 9, 2008	-0.033
	(0.078)
Period 3: September 10, 2008–December 31, 2008	-0.134***
	(0.020)
Period 4: January 2, 2009–July 31, 2009	-0.108**
	(0.045)
Negative changes in TAF outstanding	
Period 3: September 10, 2008–December 31, 2008	0.150***
	(0.016)
Period 4: January 2, 2009–July 31, 2009	0.034**
	(0.015)
Positive changes in swap outstanding	
Period 1: August 1, 2007–March 9, 2008	-0.957***
	(0.050)
Period 2: March 10, 2008–September 9, 2008	0.036
	(0.066)
Period 3: September 10, 2008–December 31, 2008	-0.084
	(0.083)
Period 4: January 2, 2009–July 31, 2009	0.204
	(0.161)
Negative changes in swap outstanding	
Period 1: August 1, 2007–March 9, 2008	-0.304***
	(0.036)
Period 2: March 10, 2008–September 9, 2008	-0.087*
	(0.050)
Period 3: September 10, 2008–December 31, 2008	0.063
	(0.045)
Period 4: January 2, 2009–July 31, 2009	0.021
	(0.015)
Constant	0.252
	(0.264)
Risk variables included?	Yes
Adjusted R^2	0.19
Observations	475

Source: Authors' calculations, based on data from the British Bankers' Association, Haver Analytics, the Board of Governors of the Federal Reserve System, foreign central banks, the Federal Reserve Bank of New York, and Markit.

Notes: Newey-West standard errors (five lags) are in parentheses. Negative changes in TAF outstanding did not occur until Period 2. The full sample is daily observations from January 3, 2007, to July 31, 2009. TAF is the Term Auction Facility. See Table 1 for a description of variables.

*** p<0.01.

** p<0.05.

* p<0.1.

The existence of balance-sheet constraints that bind only on the downside implies a negative relationship between the Libor-OIS spread and positive changes in the TAF and swap lines and no relationship for negative changes. We find, however, that declines in the TAF amount outstanding actually improved the Libor-OIS spread in Periods 3 and 4. This association might reflect reduced pressure on funding markets at this time, leading to declining demand at the Fed facilities and a reduced spread. Indeed, the two declines in the TAF amount outstanding during Period 3 occur in December 2008, when risk factors were already beginning to normalize. In Chart 3, one can see that by December 2008 liquidity risk had declined, as had the Libor quote dispersion, although the CDX index had remained elevated.

The results in Table 3 also shed light on the Fed's exit strategy from these programs. First, the decline in outstanding value that has occurred since the beginning of 2009 likely reflects a return by participants to market sources for funding as interbank market rates have fallen. Chart 2 supports this view by showing that the spread between Libor and the Fed facilities has been steadily decreasing since early 2009. The view is further supported by the coefficient estimates on the negative changes in the TAF and swap amounts outstanding in 2009 (Table 3), indicating that the reductions in the programs were not adversely affecting market interest rates. This result represents a potentially positive sign for the market, as it indicates that reductions in the supply of funds by the Fed have not been a negative shock.

11. Conclusion

The financial crisis has led to large reductions in asset prices and in new issuances of primary securities while affecting a wide variety of markets and institutions. Yet the magnitude of these effects appears to be disproportionate to the relatively small losses that occurred in the subprime mortgage markets. To explain this seeming disparity, our paper surveys the literature on financial amplification mechanisms, focusing on the balance-sheet and adverse-selection channels. It then discusses and interprets the Federal Reserve's actions during the crisis in terms of the literature. We show that the Fed's early-stage liquidity programs were mainly designed to dampen the balance-sheet amplification arising from the positive feedback between financial constraints and asset prices. The Fed's later-stage crisis programs take into account the adverse-selection amplification that operates through increases in credit risk and the externality imposed by risky borrowers on safe ones.

We also examine how changes in the Fed's supply of liquidity (the amount of funds outstanding at the TAF and swap facilities) are associated with changes in interest rate spreads, after controlling for credit risk and short-term funding conditions. We find that an increase in the supply of funds is associated with a reduction in the Libor-OIS spread early in the crisis. During more recent periods, the Fed has been gradually withdrawing funds from these programs. We find that the reduced supply of funds has had no significant impact on interest rate spreads in these periods. These results suggest that the potential withdrawal of liquidity by the Fed may not have an adverse effect on market prices.

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Matthew Pritsker

Informational Easing: Improving Credit Conditions through the Release of Information

1. Introduction

To ensure repayment of borrowed funds, lenders require that borrowers undergo costly credit evaluations. In the financial sector, credit often flows along chains of borrowers and lenders who are already familiar with each other's creditworthiness—a process that minimizes the cost of credit evaluations. However, if the creditworthiness of key participants along a chain is called into question, the chain can break and cut off the flow of credit to final borrowers. If enough chains in the economy break, a financial crisis can ensue, investment by final borrowers can dry up, and output can decline.

The flow of credit can stop because a lender believes a borrower has a high default probability or because a lender is uncertain about whether a borrower has a high default probability. The latter may often be the more likely scenario. For example, in a classic bank run, it is unlikely that depositors know the probability that their bank will become insolvent, but it is likely that they worry about the possibility that their bank has high default probability and withdraw their deposits as a precaution.[1]

More generally, a decision maker faces risk if the outcomes in his decision problem are random; he faces uncertainty if the outcomes are random and he does not know the probabilities of the outcomes.[2] For example, when lenders are uncertain, they cannot assign a single figure to a borrower's default probability, so they instead assign a range. During economic expansions, this range may be small, such as 1/4 to 1/2 percent; however, during economic downturns, the range may be 2 to 5 percent. If a lender is uncertainty-averse in the sense of Gilboa and Schmeidler (1989), it will charge spreads based on the high end of its range. This decision will be unimportant during expansions, when the range is narrow, but during downturns the required spread may be so high that a borrower cannot afford a loan—and the flow of credit from that borrower to any borrowers farther along the lending chain will be cut off.[3]

This paper addresses how central banks can resuscitate lending chains by providing information that reduces

[1] Easley and O'Hara (2009) argue that deposit insurance was instituted to eliminate bank runs motivated by uncertainty among small depositors because it allays the worries of small depositors that their bank will become insolvent. In a similar vein, Caballero and Krishnamurthy (2008) model an excessive flight to quality and flight to liquid assets that can occur when there is uncertainty over the timing of liquidity shocks—and argue for government intervention aimed at reversing the flight.

[2] For examples of different methods of modeling decision making under uncertainty in nondynamic settings, see the discussion and approach in Rigotti and Shannon (2005) as well as the approaches in Klibanoff, Marinacci, and Mukerji (2005) and Easley and O'Hara (2009). For an overview of uncertainty in dynamic settings, see Hansen and Sargent (2007) and their references.

[3] In this paper, the terms "lending chain" and "credit chain" are used interchangeably.

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uncertainty about participants along the chains. This action has been taken before: the Bank Holiday of 1933, declared by President Franklin Delano Roosevelt, resolved uncertainty about the health of individual banks by using bank inspections to publicly identify which banks were sound. This event restored the flow of funds to the banking sector and facilitated bank lending. During the 2007-09 financial crisis, the Federal Reserve used "stress tests" to measure and report on the health of large banks in the U.S. banking system and to identify those banks that required shoring up through capital injections.

In addition to providing information to the financial sector, central banks have other tools at their disposal to revive lending. When credit chains involve financial intermediaries such as banks, central banks can lower their target rates to reduce intermediaries' costs of borrowing, accept a wider range of collateral, guarantee interbank loans, or shore up banks' health through capital injections. Alternatively, they can bypass intermediaries altogether and lend directly to final borrowers in credit chains.

Each of these tools has merit in some situations—but none is perfect. Monetary easing may lower target rates to 0, but if credit spreads remain too high, lending along credit chains may still cease. Broadening the range of acceptable collateral, loan guarantees, and government-sponsored capital injections increases lending, but it can also increase the central bank's exposure to credit and market risk. Direct lending outside the financial sector may reduce lending efficiency, because such intermediation is not a central bank's usual function.

Under conditions of less uncertainty, many of these efforts would be less costly and more effective. This statement is intuitive, as it is easier to convince potential lenders that a solvency problem has been fixed if they have better information about the scope of the problem. It follows that during a crisis, steps to reduce uncertainty through information provision should be taken as soon as possible.

In theory, information designed to reduce uncertainty could be provided privately by borrowers. However, because borrowers may have an incentive to exaggerate their financial strength during economic downturns, private information provision may lack credibility. Moreover, uncertainty reduction by borrowers upstream in a credit chain may generate external benefits to borrowers downstream that are not internalized by private information providers. As a result, the private sector may provide less than the socially optimal level of uncertainty reduction. For both these reasons, situations may arise in which government information provision to reduce uncertainty may be warranted.

The remainder of this paper is divided into two sections. In Section 2, we provide a model of credit chain lending that illustrates how uncertainty can cause credit chains to break and how government policies that reduce uncertainty can restore the flow of credit. Section 3 considers potential future uses of uncertainty reduction policies.

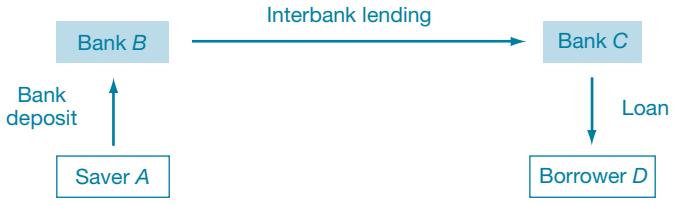
2. The Model

Our stylized model of a credit chain has four participants: *A, B, C,* and *D*, and three dates: 0, 1, and 2. Participant *A* is a short-term depositor who has excess funds at date 1 that he wants to lend until date 2. Participants *B* and *C* are banks that make long-term loans at date 0 and short-term loans at date 1. Both loan types mature at date 2. Participant *D* is a short-term borrower who unexpectedly needs a loan at date 1 that matures at date 2.

We assume that some participants are familiar with each other's credit risk based on a previous bilateral lending relationship, while others are not. In particular, *A* has previously loaned funds to *B*, *B* to *C*, and *C* to *D*. These relationships suggest a natural basis for a credit chain to form at date 1. *D* could borrow from *A*, *B*, or *C*. Since *A* and *B* are unfamiliar with *D*, a costly credit evaluation would be needed before either would extend a loan to *D*. Instead, *C* is the logical lender to *D*; but if *C* does not have the funds, then *C* will need to turn to *A* or *B* for funding. Because of previous relationships, *B* is the logical lender to *C*, and if *B* needs funds then *A* is the logical source. Thus, a short-term loan from saver *A* is intermediated to borrower *D* along a credit chain in which bank *B* makes a loan to bank *C* through the interbank market (Exhibit 1).

Because many loans are intermediated through the interbank market, the functioning of the market is important for credit extension. *C* can lend to *D* only if the maximum rate that *D* can afford to pay *C* for a loan, denoted $\overline{R_D}$, is less than *C*'s cost of funds. When *C* borrows from *B*, its cost of funds is equal to the risk-free rate R_f plus a spread S_C that reflects its credit risk. Therefore, *D* will be able to borrow from *C* only if:

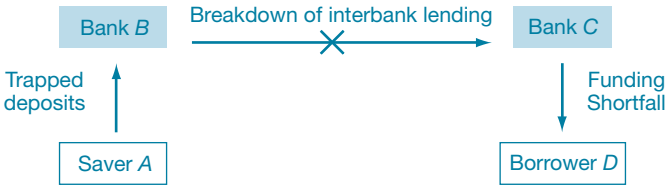
Exhibit 1
Short-Term Lending Chain



Note: Borrower *D* needs a short-term loan, and saver *A* has excess short-term funds. Because *A* and *B*, *B* and *C*, and *C* and *D* have had previous borrowing relationships, a lending chain from *A* to *B* to *C* to *D* is the least expensive way to fund *D*'s loan since there is no need for costly credit evaluations.

Exhibit 2

Broken Lending Chain



Note: If there is a breakdown of lending from *B* to *C* in the interbank market, the funds are trapped with bank *B*, and borrower *D* is short of funds.

$$R_f + S_C < \overline{R_D}. \tag{1}$$

Under normal economic conditions, the spreads that banks charge each other for loans are small and would not typically be an impediment to *D*'s borrowing. However, during the financial crisis of 2007-09, interbank spreads increased markedly, and lending through the interbank market declined. A consequence of high interbank spreads is that funds can become trapped at the wrong place, such as with bank *B* instead of borrower *D* (Exhibit 2). Whether interbank spreads increase at date 1 depends on *B*'s assessment of *C*'s default risk as of date 1. This in turn depends on *C*'s long-run asset portfolio and capital structure, both chosen at date 0.

At date 0, banks *B* and *C* both choose their long-run asset portfolios and capital structures. Since the main concern is *B*'s willingness to lend to *C*, we focus only on *C*'s portfolio choices hereafter. For simplicity, *C*'s long-run asset portfolio consists only of loans to wheat farmers (w) and oat farmers (o). The loans generate gross returns R_w and R_o at date 2 per dollar invested at date 0. The return on the loans is assumed to be multivariate normal.[4] Bank *C*'s portfolio weights are ω_w and ω_o and its portfolio generates return R_p:[5]

$$R_p = \omega_w R_w + \omega_o R_o. \tag{2}$$

To finance its long-run portfolio, *C* is endowed with equity capital *E* and insured certificates of deposit with face value *F* that mature at date 2 and pay gross interest $R^C_{0,2}$ at maturity.

At date 1, information I_1 about the return on the long-term loans arrives. Conditional on this information, the returns on the loan portfolio are distributed normally with mean μ_1 and variance σ_1^2:

$$R_p | I_1 \sim N(\mu_1, \sigma_1^2), \tag{3}$$

where the parameters μ_1 and σ_1^2 depend on the portfolio weights as well as the means, standard deviations, and correlation of the assets' returns, given the information available at date 1 (see Appendix A).

Additionally, recall that at date 1 bank *C* has the opportunity to extend a short-term loan to *D* that matures at date 2, which it needs to fund in the interbank market by borrowing from *B*.[6]

The spread that bank *C* pays on its interbank loans depends on bank *B*'s perception of the probability that *C* will default on its debt at date 2. We assume that bank *C*'s long-term loan portfolio is so much larger than its short-run lending opportunities that the performance of its short-run loans and their funding does not affect whether *C* will default. Under this assumption, *C* will default only if the value of its long-term loan portfolio at date 2 is less than what is owed on its deposits:

$$(F + E)R_p < FR^C_{0,2}. \tag{4}$$

From this expression, we show that bank *C*'s probability of default—and therefore the loan spread that *B* charges *C*—depends on *C*'s portfolio weights, financial leverage *L* ($L = F/E$), and the parameters of the return distribution of *C*'s loan portfolio.

We assume that the risk inherent in both types of loans is known by bank *B*, as is *C*'s leverage, since leverage information is usually readily available. However, *B* does not know *C*'s portfolio weights. There are two cases to consider: The first is that *B* has beliefs about *C*'s portfolio that are sufficiently well formed as to be described by a unique prior probability distribution, which means that for each portfolio that *C* could hold, *B* assigns a single probability number to the likelihood that *C* could hold that portfolio. In this first case, *B*'s assessment of *C*'s probability of default is just a single number given by the sum of *C*'s default probability for each portfolio it could hold multiplied by *B*'s belief about the probability that *C* will hold that portfolio.[7] Because *B*'s assessment of *C*'s default probability is a single figure, *B* is not uncertain about *C*'s default probability.

The second case is that *B* does not know enough about *C*'s portfolio weights, and *B*'s beliefs cannot be described by a unique prior probability distribution. Instead, *B* may be uncertain about the portfolio weights and thus may hold

[4] Pritsker (2009) illustrates conditions under which the average return on loans to a diversified group of borrowers can be approximately normally distributed even if the returns to individual borrowers are not.

[5] The portfolio weights are each assumed to be greater than or equal to 0 and to sum to 1.

[6] Bank *C* may fund some of its short-term loans in the interbank market because it did not fully anticipate the short-term loan demand or because the interbank market is usually an inexpensive funding source.

[7] For example, suppose *B* believes *C* holds only one of two portfolios, 1 or 2, and the probability that *C* holds 1 or 2 is 0.3 and 0.7, respectively. Also suppose the probability that portfolio 1 defaults is .01 and the probability that portfolio 2 defaults is .02. Then, *B* believes the probability that *C* defaults is given by $PD = 0.3 \times 0.01 + 0.7 \times 0.02$.

multiple priors over the weights. Thus, *B* assigns a range of probabilities to some or all of the portfolio holdings that *C* may have. For example, if bank *B* is asked about the probability that *C* holds a portfolio with a weight of 0.4 in loans to oat farmers and 0.6 in loans to wheat farmers, *B* might respond that it is unsure, but it believes the probability ranges from 10 to 20 percent.[8]

There are many reasons why *B* might be uncertain about *C*'s portfolio composition. For example, *C* may have a very complex portfolio, and thus researching *C*'s holdings in extensive detail may be very expensive. This may be true for *C*'s portfolio because it consists of loans to farmers, and it may be very difficult for *B* to verify which loans are to oat or wheat farmers because this information may not be readily available, and it may be costly to obtain.[9] Information costs are important because many of the most active banks in the U.S. interbank market have more than $1 trillion of assets on their balance sheets, and ascertaining the loan composition, or even learning enough to form a unique prior probability distribution about the balance-sheet composition, can be very expensive.

A simple and parsimonious way to model multiple priors is to assume that bank *B* knows *C* makes only long-term loans to oat and wheat farmers, and that *B* knows *C* has risk concentration limits that prevent it from making more than 60 percent of its loans to one type of farmer—and that is all *B* knows about *C*'s portfolio. Given its information, bank *B* knows that *C* could have a set of possible portfolios, and that the weight on wheat is a number t between 0.4 and 0.6 and that the weight on oats is $1 - t$. Given bank *B*'s information, it does not know the probability that *C* will hold any particular portfolio, but it does know the probability that *C* will default on each portfolio that it could hold. From this information, bank *B* can compute a range of possible default probabilities for bank *C*. The range can be written as

$$PD \in [\underline{PD}, \overline{PD}] \ ,$$

meaning that based on bank *B*'s information about bank *C*, bank *B* believes *C*'s default probability lies within a range between a lower bound $\underline{PD}$ and an upper bound $\overline{PD}$.

The fact that *B* assigns a range of possible default probabilities to *C* is precisely the type of situation described in the introduction to this paper. The above logic, formally derived in Appendix A, shows that the result of *B*'s uncertainty about *C*'s portfolio weights is that *B* assigns a range of possible values to *C*'s probability of default. The spread that *B* charges *C* will depend on the range of uncertainty that *B* has about *C* and on *B*'s preferences. In particular, if bank *B* sets spreads in an uncertainty-averse fashion, as in Gilboa and Schmeidler (1989), then *B* will set *C*'s spread as if it believes *C*'s default probability is equal to $\overline{PD}$, the upper end of its range. Other decision rules for setting spreads in the face of uncertainty are plausible. It seems reasonable to believe that for many rules, all else equal, *B* would charge a higher spread when the upper end of the range of possible default probabilities increases.

For illustrative purposes, we assume that in the face of uncertainty, there are many banks like *B* that set spreads in an uncertainty-averse fashion. As a consequence, banks like *C* will pay a premium for uncertainty. More specifically, let PD^* denote *C*'s true default probability, and for simplicity assume that bank *B* is risk-neutral and uncertainty-averse. In this circumstance, if at date 1 bank *B* can invest at the risk-free rate between dates 1 and 2, or bank *B* can lend to bank *C* at interbank rate $R^C_{1,2}$, then for *B* to be indifferent between the two, $R_f = R^C_{1,2}(1 - \overline{PD})$, which implies $S_C = R^C_{1,2} - R_f$ is given by:

$$S_C = R_f \frac{\overline{PD}}{1 - \overline{PD}} .$$

Suppose *C*'s true *PD* at time 1 based on all information is PD^*. Then if PD^* was known by *B*, *C*'s spread based on risk alone but not uncertainty would be

$$S^*_C = R_f \frac{PD^*}{1 - PD^*} .$$

Because of uncertainty and uncertainty aversion, bank *C*'s spread will consist of the risk premium S^*_C plus an additional uncertainty premium given by:

$$S_C - S^*_C = R_f \left[\frac{\overline{PD}}{1 - \overline{PD}} - \frac{PD^*}{1 - PD^*} \right].$$

If *B* sets its spread based on its worst-case-scenario beliefs about *C*'s default probability, then the uncertainty premium will always be positive. The size of the uncertainty premium paid by bank *C* depends on *C*'s capital structure as well as the conditional expected return and volatility of its loan portfolio. To analyze the uncertainty premium, we compute the premium when *C*'s loan portfolio is split evenly between oats and wheat. Our analysis shows that the uncertainty premium can be very low when leverage is low, but it can also be low when leverage is high, provided that economic conditions are favorable enough. In particular, all else equal, for reasonable parameter values, uncertainty premia are lower when the volatility of the returns on both types of loans is low, when the expected returns on both types of loans is high, or in both circumstances (Charts 1 and 2).[10] This explains how banks can

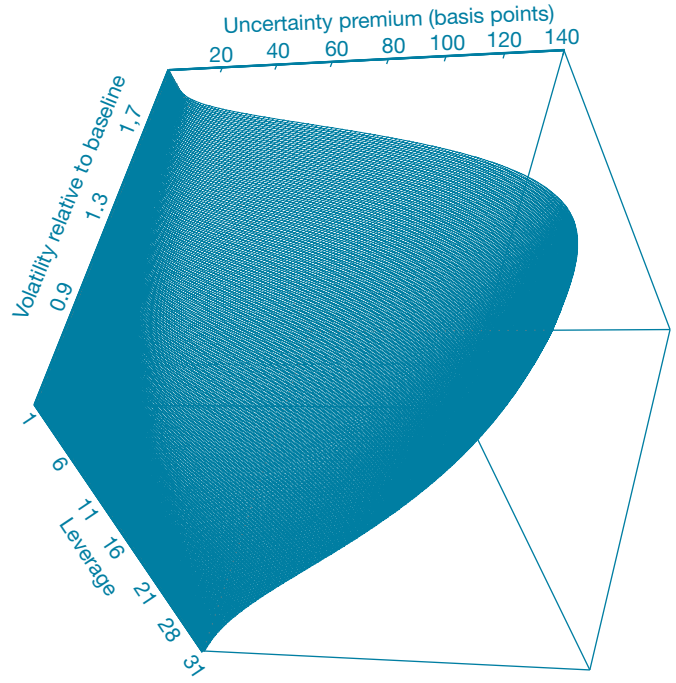
[8] Knowledge of bank *B*'s portfolio weight in one of the risky assets is sufficient to describe its portfolio because its weight in the other risky asset is 1 minus the weight of the first asset.

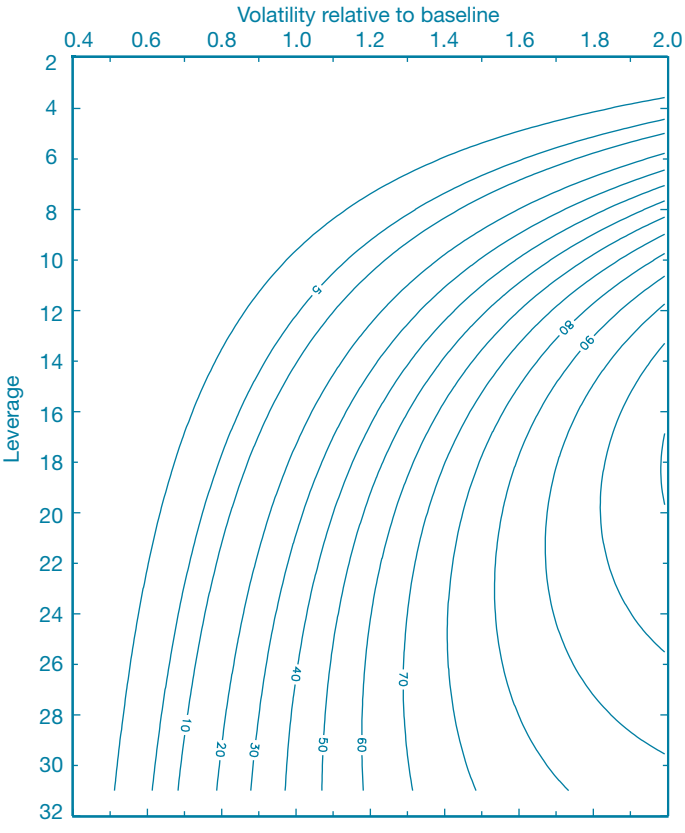
[9] Gorton (2008, 2009) argues that uncertainty about the types of assets collateralizing asset-backed securities was an important factor behind the 2007-09 credit crisis.

[10] The simulations are for illustrative purposes. Details are available from the author upon request.

Chart 1

Uncertainty Premium as a Function of Leverage and Loan Volatility



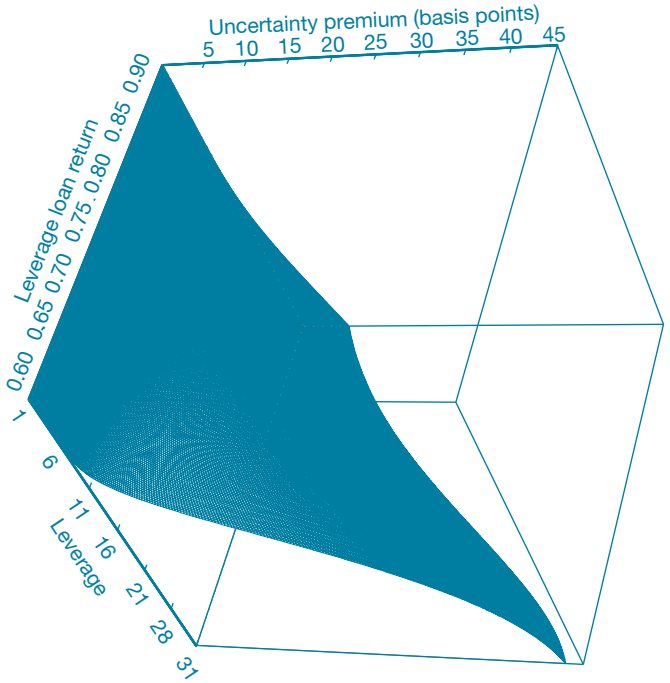


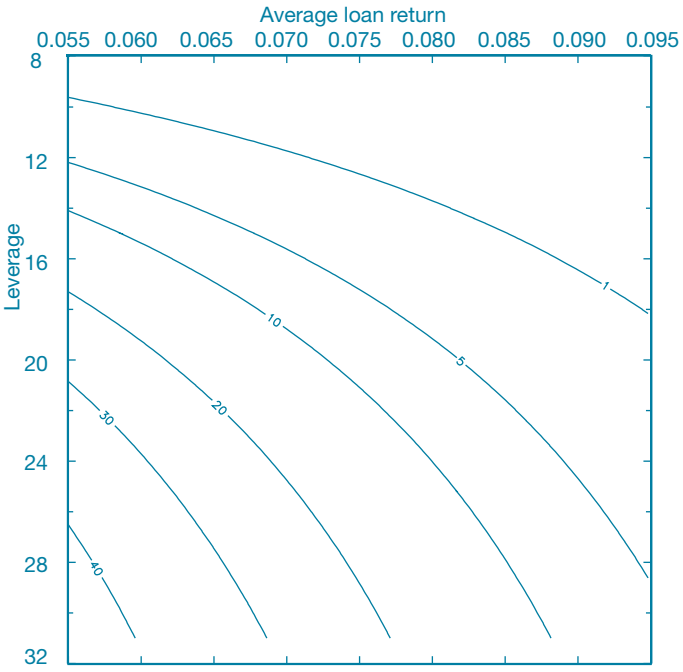
Source: Author's calculations.

Note: For the stylized risky loan portfolio held by bank *C*, the chart presents surface and contour plots of the uncertainty premium that bank *C* pays for its short-term unsecured interbank borrowing as a function of *C*'s leverage and as a function of the volatility (standard deviation) of *C*'s assets relative to their baseline volatility.

Chart 2

Uncertainty Premium as a Function of Leverage and Average Loan Return



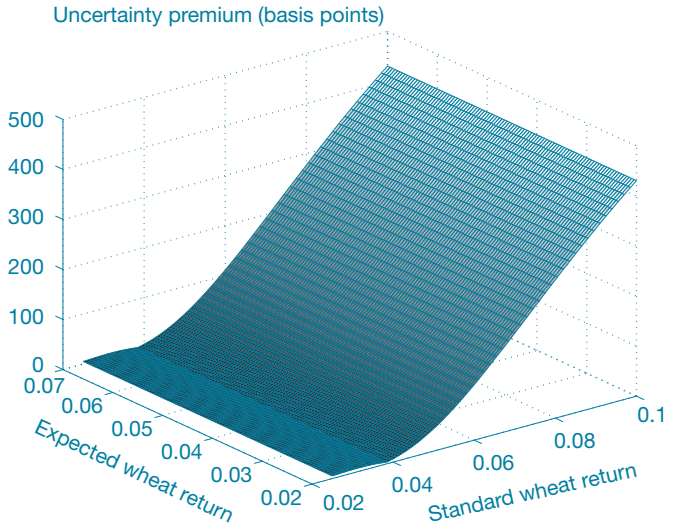


Source: Author's calculations.

Note: For the stylized risky loan portfolio held by bank *C*, the chart presents surface and contour plots of the uncertainty premium that bank *C* pays for its short-term unsecured interbank borrowing as a function of *C*'s leverage and as a function of the average return on its loans when the average return on each loan in its portfolio is increased or decreased by the same amount.

Chart 3

Uncertainty Premium as a Function of Sector Performance



Source: Author's calculations.

Note: For the stylized loan portfolio held by bank *C*, the chart presents *C*'s uncertainty premium as a function of the performance of loans to wheat farmers, one of two types of long-term loans extended by *C*. The chart shows that the uncertainty premium grows when loans to wheat farmers become more risky, and when the expected return on loans to wheat farmers decreases.

often be uncertain about each other's portfolio composition, and yet because of their choice of capital structure they can usually lend and borrow from each other while charging low spreads. The analysis also shows that banks may be able to take on very significant leverage during very prosperous times, and still pay only a small uncertainty premium. In fact, this roughly describes the situation prior to the global financial crisis of 2007-09, because before that time volatility was considered very low by historical standards, the spread paid by banks was low, and yet bank leverage was fairly high (Chart 1, bottom panel).

During the crisis, the bursting of the housing bubble heralded the arrival of bad news about the housing sector. Interbank spreads increased appreciably because of uncertainty over which banks were exposed to housing—and especially uncertainty over which banks were exposed to subprime loans. To understand the same effects for bank *C*, suppose the bad news is a wheat blight that increases the likelihood that wheat farmers default on their loans, and thereby increases the volatility and decreases the expected returns on loans to wheat farmers. For given leverage, these changes can have a dramatic effect on the uncertainty premium paid by bank *C*. As illustrated in Chart 3, the bank's uncertainty premium ranges from near 0 when volatility is low and expected returns are high to several hundred basis points when expected returns are low and volatility is high. The result of the elevated premium is high interbank spreads that cause borrowers such as *D* to lose access to their funding.

A government-sponsored stress test would reveal information on bank *C*'s solvency, through a publicly released assessment of *C*'s financial health, the release of summary information on *C*'s risk exposures, or a combination of the two. There is a strong case for doing both. For example, recall that government action may be needed to reduce uncertainty when the private costs of providing information to reduce uncertainty are too high. There are two sources of costs: The first is the cost of compiling and disclosing the information on risk exposures at the finer level of detail that is required during economic downturns. This is a nontrivial cost for very large banks. The second is the cost of processing the information on risk exposures to make inferences about the bank's solvency risk. If the second cost is high enough, then some potential lenders to *C* will not be able to process the information on exposures, and thus would be unwilling to lend to *C*. For this reason, the government may have to intervene to provide processed information on the bank's health, which it did as part of the recent Supervisory Capital Assessment Program stress testing in the United States. In that case, the information provided was the amount of capital injection required by banks to ensure capital adequacy during a particular stress scenario that was common across banks. The case for releasing better information on exposures is that the information provides more detail on bank portfolios that further reduces the uncertainty premia charged by lenders that can process the exposure information.

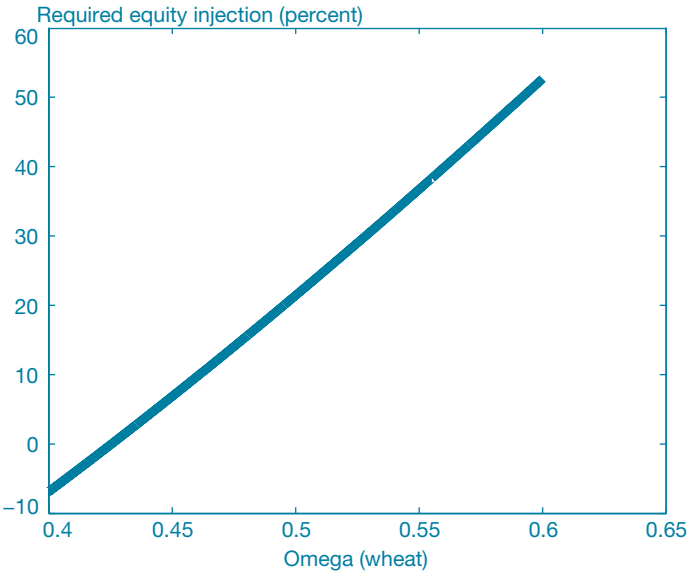
Under ideal circumstances, *C*'s true condition would be revealed by the stress tests, all uncertainty about its risk exposures would be eliminated, and its uncertainty spread would decrease to 0. More realistically, stress tests will reduce, but not eliminate, uncertainty spreads because although they may eliminate uncertainty over risk exposures, other sources of uncertainty may remain (such as uncertainty over the correct form of pricing models for some assets).

If the information revealed by the stress test about *C* is favorable enough, then *C* will be able to borrow from *B* to lend to *D* and the chain of credit will be restored. If instead it is learned that *C*'s balance sheet is weak, or its loans are not performing, then additional steps, such as bank equity injections or temporary government-sponsored guarantees on interbank lending, may be warranted.

Equity injections and government-sponsored loan guarantees can both be implemented without a stress test. The value-added benefit of the stress test is its ability to make these other steps more cost-effective if lenders are uncertainty-averse.

Chart 4

Size of Equity Injection Required to Restore Lending



Source: Author's calculations.

Note: For the set of different long-term loan portfolios that bank *C* could possibly hold, indexed by omega—the fraction of long-term loans extended to wheat farmers—the chart presents the percentage increase in *C*'s equity (the required equity injection) that would be needed to restore *C*'s ability to acquire a short-term loan from bank *B* to finance a loan to borrower *D*. If bank *B* is uncertainty-averse, and does not know *C*'s portfolio, it will require a conservative equity injection of 50 percent before lending. If *B* becomes familiar with *C*'s portfolio, the required equity injection will be smaller, and could be negative.

Consider first an equity injection into bank *C*. If bank *C* is to restart lending to borrowers such as *D*, a sufficient amount of equity must be injected to bring bank *C*'s spread down to the level

$$S_C = \bar{R}_D - R_f.$$

If the equity injection occurs before the stress test, then *B* remains uncertain about *C*'s portfolio, and consequently a large amount of equity will be required to bring *C*'s loan spread down. This scenario is depicted in Chart 4, with details provided in Appendix B. In the chart, *C* needs to inject enough equity to bring its perceived probability of default down to 2 percent. If *B* is uncertainty-averse, it will charge spreads based on the most pessimistic beliefs about *C*'s portfolio, which correspond to a portfolio invested 60 percent in wheat, attributable to the wheat blight. In this case, *C* will need to increase the equity in the bank by about 50 percent to drive down *B*'s lending rate sufficiently so that *C* can lend to *D*.

If the stress test was instead conducted before the equity injection, then *B* would discover *C*'s portfolio holdings, eliminating the uncertainty. If *B* is uncertainty-averse, then because *C*'s holdings can be no worse than the worst case, the amount of equity it will need to inject is smaller. For example, if *C*'s true portfolio is split evenly in each type of loan, the size of the required equity injection would be only about 20 percent, and in some cases no equity injection would be required.[11]

For similar reasons, stress tests reduce the costs and increase the effectiveness of government programs that guarantee interbank loans. To illustrate, we note that interbank loan guarantees are very expensive because they transfer credit risk from the banking system to the government. Therefore, in the United States the guarantees offered by the Federal Deposit Insurance Corporation were limited as to the amount of new interbank lending that was guaranteed, and banks that participated in the program were charged a fee based on the amount borrowed. While the fees and limitations on the amount of new loans that are covered reduce the government's exposure as a guarantor of interbank loans, they also limit banks' ability to borrow under these programs.

If a stress test is conducted before the loan guarantee program is put in place, then the test may help the market distinguish low- from high-risk banks. The banks that are identified as low risk may then be able to borrow more at better rates than the loan guarantee program could provide; thus, they could potentially increase lending while saving money.

Finally, stress tests and other programs to restart lending may work better in combination than alone. For example, in equation 1, lowering R_f to 0 may be insufficient to restart lending, and eliminating the uncertainty spread without lowering R_f may also be insufficient—but both actions together may be sufficient.

3. Conclusion

When credit is provided along chains of borrowers and lenders, uncertainty over borrowers' economic conditions can sometimes cause the flow of credit to break down. However, when a breakdown occurs, a central bank can take action to restart the flow of credit. One such action is to reduce uncertainty through government provision of information on financial intermediaries, such as banks, that are key links in lending chains. Information provision works by reducing those components of borrowers' credit spreads attributable to uncertainty over their economic conditions. Because information provision can reduce the interest rates paid by borrowers, it can be viewed as a substitute for easing interest

[11] For details, see Appendix B.

rates by other means, such as lowering central bank target rates, and may prove especially useful when central bank target rates are at their lower bounds.

Although government-sponsored information provision may improve the flow of credit ex post, its use has been—and probably should be—relatively infrequent for two reasons. First, gathering information is costly, and the benefits of providing it, in terms of lower spreads, will probably not exceed the costs in many circumstances. Second, government provision of information is a two-edged sword: It may be needed to reduce uncertainty ex post because private incentives to do the same are inadequate ex ante. However, government information provision ex post may further worsen private incentives to choose capital structures and transparent portfolio holdings that reduce uncertainty spreads. Thus, in the future, perhaps central banks should be concerned with uncertainty reduction ex post and with efforts to improve private incentives to reduce uncertainty ex ante.

Appendix A: Details of Model Derivation

We show how bank *B* calculates a range of possible default probabilities for bank *C* when bank *B* is uncertain about *C*'s portfolio holdings.

As we discuss in the text, the returns on two types of loans, to wheat farmers (w) and to oat farmers (o), conditional on the information known at date 0, are multivariate normal. At date 1, news arrives. Conditional on I_1, the information that is known at date 1, the return on bank *C*'s assets is multivariate normal with means μ_w and μ_o, standard deviations σ_w and σ_o, and correlation parameter $\rho_{w,o}$. Therefore, the conditional distribution of the return on the long-term loan portfolio is given in equation 2, with parameters μ_1 and variance σ_1^2 as follows:

$$\text{(A1)} \qquad \mu_1 = \omega_w \mu_w + \omega_o \mu_o \ ,$$

$$\text{(A2)} \qquad \sigma_1^2 = \omega_w^2 \sigma_w^2 + \omega_o^2 \sigma_o^2 + 2\,\omega_w \omega_o \sigma_o \sigma_w \rho_{w,o} \ .$$

Bank *C* will default at date 2 under the condition in equation 4. The bank's probability of default conditional on the information known at date 1 is given by:

$$\text{(A3)} \qquad PD(\omega_w, \omega_o, L, 1) = \Phi\left(\frac{\frac{L}{1+L} R_{0,2}^C - \mu_1}{\sqrt{\sigma_1^2}}\right),$$

where ω_w and ω_o are bank *C*'s portfolio weights, μ_1 and σ_1^2 are the mean and variance of the portfolio's return distribution given the portfolio weights (equations A1 and A2), and $\Phi(.)$ is the cumulative distribution function of the standard normal distribution.

To model uncertainty about *C*'s portfolio weights, we assume that *B* knows that *C* could have a set of possible portfolios, and that the weight on wheat is some number t between 0.4 and 0.6 and the weight on oats is $1 - t$. More formally, *C*'s possible portfolios can be written as

$$\omega_w = t \,,\ \omega_o = 1 - t \,,\ t \in [0.4, 0.6] \,.$$

Given the available information, bank *B* does not know the probability that *C* will hold any particular portfolio; however, from equation A3 bank *B* does know the probability that *C* will default on each portfolio that it could hold. The set of default probabilities is given by the probability of default in the equation below for different choices of *t*:

$$\text{(A4)} \quad PD(t) = PD(\omega_w = t, \omega_o = 1 - t, L, 1) \,,\ t \in [0.4, 0.6] \,.$$

Therefore, given the set of possible portfolios, we have a range of possible default probabilities that bank *C* could have.

Appendix B: Solving for the Size of Bank *C*'s Required Equity Injection

We solve for the size of the equity injection needed to sustain interbank lending from bank *B* to bank *C* when there is uncertainty about bank *C*'s portfolio holdings and when bank *B* knows *C*'s portfolio composition because it has been revealed as part of a stress test.

When there is uncertainty about bank *C*'s portfolio holdings, an uncertainty-averse lender will assess the default risk as equal to $\overline{PD}$, which is the highest default probability that bank *C* could have, given its possible portfolio holdings:

$$\overline{PD} = \max_{t \in [0.4,\ 0.6]} PD(\omega_w = t,\ \omega_o = 1 - t,\ L,\ 1),$$

where *PD(.)* is defined in equation A3. Provided that $\overline{PD} < 0.5$, which is very plausible, Pritsker (2009) shows that *PD(.)* is a convex function of the portfolio weights. Therefore, the problem of solving for $\overline{PD}$ maximizes a convex objective function over a convex set. It follows that the solution is on the boundary, at either $t = 0.4$ or $t = 0.6$.

Using the expression for *PD(.)*, $\overline{PD}$ can be expressed as

$$\overline{PD} = \Phi\left(\frac{\frac{L}{1+L}R^C_{0,2} - \overline{\mu}_1}{\sqrt{\overline{\sigma}_1^2}}\right),$$

where $L = F/E$; $\overline{\omega}_w$ and $\overline{\omega}_o$ are the portfolio weights for the portfolio that generates the maximum probability of default; and $\overline{\mu}_1$ and $\overline{\sigma}_1$ are the mean and standard deviation, respectively, of the return on the portfolio that maximizes *C*'s default probability.

Solving the above equation for *E*, it then follows that the original amount of equity capital in bank *C*, denoted E_0, is:

$$E_0 = \frac{F[R^C_{0,2} - (\overline{PD}\,\overline{\sigma}_1 + \overline{\mu}_1)]}{\overline{PD}\,\overline{\sigma}_1 + \overline{\mu}_1}.$$

Let PD^T, "the *PD* target," denote the required maximum level of *PD* for which it is possible to support an interbank loan between banks *B* and *C* when *B* is uncertainty-averse. From the above equation it follows that, holding *F* constant, the amount of equity in *C*'s capital structure needed to reduce its maximum level of *PD* to PD^T is

$$E_{T,\,NI} = \frac{F[R^C_{0,2} - (PD^T\overline{\sigma}_1 + \overline{\mu}_1)]}{PD^T\overline{\sigma}_1 + \overline{\mu}_1}$$

when information to reduce uncertainty is not provided (*NI* is no information).

When information is provided to reduce uncertainty, revealing *C*'s portfolio weights, then the amount of equity needed in *C*'s capital structure is

$$E_{T,\,I} = \frac{F[R^C_{0,2} - (PD^T\sigma_1 + \mu_1)]}{(PD^T\sigma_1 + \mu_1)},$$

where *I* is information.

When uncertainty is unresolved, the percentage equity injection that is required is $100 \times (E_{T,\,NI}/E_0 - 1)$; when information is provided that resolves uncertainty, it is $100 \times (E_{T,\,I}/E_0 - 1)$. The percentage equity injections are reported in Chart 4 in the text for different initial portfolios $\omega(t)$.

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Systemic Risk and Deposit Insurance Premiums

1. Introduction

While systemic risk—the risk of wholesale failure of banks and other financial institutions—is generally considered to be the primary reason for supervision and regulation of the banking industry, almost all regulatory rules treat such risk in isolation. In particular, they do not account for the very features that create systemic risk in the first place, such as correlation among banks' investments (Acharya 2009; Acharya and Yorulmazer 2007, 2008); the large size of some banks (O'Hara and Shaw 1990),[1] which leads to "fire-sale"–related pecuniary externalities; and bank interconnectedness (Allen and Gale 2000; Kahn and Santos 2005). In this paper, we aim to fill this important gap in the design of regulatory tools by providing a normative analysis of how deposit insurance premiums could best be structured to account for systemic risk.

Demand deposits are explicitly or implicitly insured in most countries up to some threshold amount per individual (or deposit account). While regulators in some countries have realized the need to establish a deposit insurance fund only during the 2007-09 financial crisis, others have established funds much earlier. Demirgüç-Kunt, Karacaovali, and Laeven (2005) show that most countries provide deposit insurance. Furthermore, during the crisis of 2007-09, some countries, including developed countries such as Australia and New Zealand, introduced guarantees for the first time, whereas a significant majority of others increased their insurance coverage. In most cases, the capital in these deposit insurance funds is the reserve built up over time through the collection of insurance premiums from banks that receive the benefits of deposit insurance. Yet how should such premiums be charged?

We argue that the extent of systemic risk in the financial sector is a key determinant of efficient deposit insurance premiums. The basic argument is as follows. When a bank with insured deposits fails, the deposit insurance fund takes over the bank and sells it as a going concern or piecemeal. During periods of widespread bank failure, it is difficult to sell failed banks at attractive prices because other banks are also experiencing financial constraints (Shleifer and Vishny 1992; Allen and Gale 1994). Hence, in a systemic crisis, the deposit insurance fund suffers from low recovery from the liquidation of failed banks' assets. This, in turn, leads to higher drawdowns per dollar of insured deposits. This argument gives our first result: *the actuarially fair deposit insurance premium—the premium that exactly covers the expected cost to the deposit insurance provider—should not only increase in relation to individual bank failure risk but also in relation to joint bank failure risk.*[2]

[1] Only recently, the Federal Deposit Insurance Corporation (FDIC) announced a special assessment, to be collected on September 30, 2009, that will be computed based on total assets (minus "tier 1" capital). See http://www.fdic.gov/deposit/insurance/assessments/proposed.html.

[2] Pennacchi (2006) shows that if insurance premiums are set to a bank's expected losses and fail to include a systematic risk premium, banks that make investments with higher systematic risk enjoy a greater financing subsidy relative to banks that make investments with lower systematic risk.

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In addition, the failures of large banks lead to greater fire-sale discounts. This occurrence has the potential to generate a significant pecuniary externality that can have adverse contagion-style effects on other banks and the real economy (compared with the effects stemming from the failure of smaller banks).[3] Hence, the resolution of large banks is more costly for the deposit insurance regulator, directly in terms of losses from liquidating large banks and indirectly from contagion effects. This leads to our second result: *the premium for large banks should be higher per dollar of insured deposit compared with that for small banks.*

Furthermore, bank closure policies reflect a time-inconsistency problem (see, for example, Mailath and Mester [1994] and Acharya and Yorulmazer [2007, 2008]). In particular, regulators ex ante would like to commit to being tough on banks even when there are wholesale failures to discourage banks from ending up in that situation. However, this strategy is not credible ex post, and regulators show greater forbearance during systemic crises. While such forbearance among most regulators around the world has been a feature of the current crisis, it has a strong precedent. For example, Hoggarth, Reidhill, and Sinclair (2004) study resolution policies adopted during thirty-three international banking crises from 1977 to 2002. They document that when faced with individual bank failures, authorities have typically sought a private sector resolution in which the losses have been passed on to existing shareholders, managers, and sometimes uninsured creditors—but not taxpayers. Still, government involvement has been an important feature of the resolution process during systemic crises: at early stages, liquidity support from central banks and blanket government guarantees have been granted, usually at a cost to the budget; bank liquidations have occurred very infrequently, and creditors have rarely suffered any losses.

Such forbearance during systemic crisis creates incentives for banks to herd and become interconnected; thus, when they fail, they do so with others—and this increases their chance of a bailout. Given this collective moral hazard, we obtain our third and final result: *the incentive-efficient premium that discourages banks from excessive correlation in their investments features a higher charge for joint bank failure risk than the actuarially fair premium*. In other words, from a normative standpoint, the deposit insurance premium charged to banks is increasing in systemic risk.

The remainder of our paper is organized as follows. Section 2 offers a brief history of the FDIC and deposit insurance premiums. In Section 3, we describe a model we have developed to provide normative analysis of deposit insurance premiums. Section 4 derives the actuarially fair deposit insurance premium as a function of systemic risk separately for large and small banks. In Section 5, we consider the role of forbearance and derive the incentive-efficient deposit insurance premium—taking into account all potential costs associated with the resolution of failed banks, such as the cost of inefficient liquidations and bailouts—and compare it with the actuarially fair premium. Section 6 concludes.

[3] Such effects have epitomized the current crisis—especially the failures of Lehman Brothers and (effectively) AIG, although they are not deposit-insured entities.

2. The FDIC and Deposit Insurance Premiums

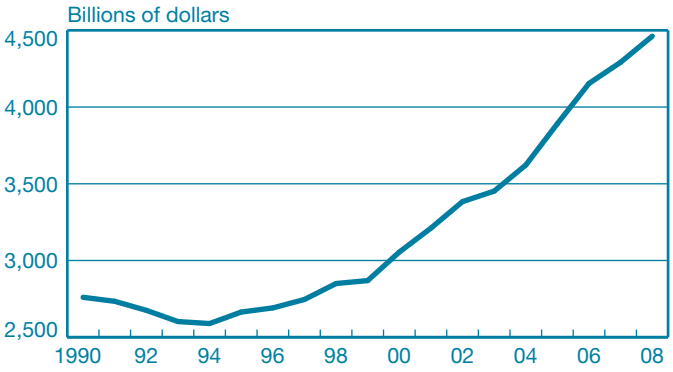
While the three principles used to determine efficient deposit insurance premiums apply generally, it is useful to consider them in the context of how premiums have been priced in the United States. Accordingly, we briefly discuss the Federal Deposit Insurance Corporation—the U.S. deposit insurance regulator—and the premium schemes that have been used in the United States.[4]

In response to the devastating effects of the Great Depression, the U.S. government established the FDIC in 1933 to insure deposits of commercial banks and prevent banking panics. The FDIC's reserves began with a $289 million capital injection from the U.S. Treasury and the Federal Reserve in 1934. Throughout most of the FDIC's history, deposit insurance premiums have been independent of bank risk, mainly because of the difficulty assessing that risk. Between 1935 and 1990, the FDIC charged flat deposit insurance premiums at the rate of approximately 8.3 cents per $100 of insured deposits. However, in 1950, the FDIC began to rebate some of the collected premiums. The rebates have been adjusted to target the amount of reserves in the FDIC's deposit insurance fund (DIF).

While the banking industry usually wanted deposit insurance assessments to be set at a relatively low level, the FDIC preferred that premiums be high enough for the reserves to cover future claims from bank failures. In 1980, the DIF was given a range of 1.1 percent to 1.4 percent of total insured deposits. However, as a result of a large number of bank failures during the 1980s, the DIF was depleted. Subsequently, the Financial Institutions Reform, Recovery, and Enforcement Act of 1989 mandated that the premiums be set to achieve a 1.25 percent designated reserve ratio (DRR) of reserves to total insured deposits. (Chart 1 shows total deposits insured by the FDIC; Chart 2 displays the balances of the DIF and the reserve ratio for the 1990-2008 period.)

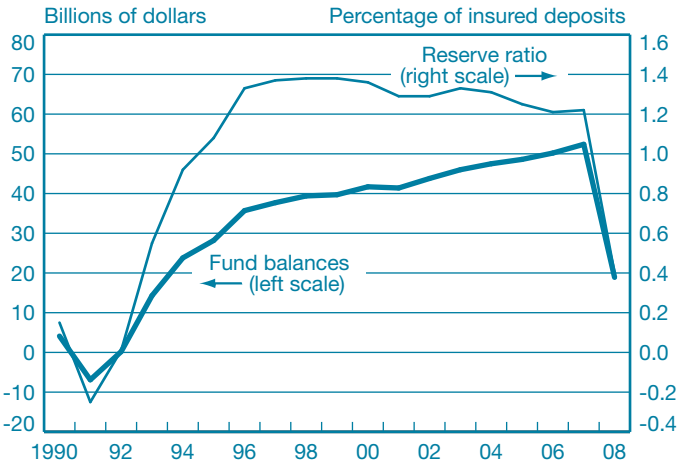
[4] Our discussion is based largely on Pennacchi (2009) and Cooley (2009); also see Saunders and Cornett (2007).

Chart 1
Total Deposits Insured by FDIC



Source: Federal Deposit Insurance Corporation (FDIC).

Chart 2
Balances of Deposit Insurance Fund and the Reserve Ratio



Source: Federal Deposit Insurance Corporation.

The bank failures of the 1980s and early 1990s led to reforms in the supervision and regulation of banks; these included the Federal Deposit Insurance Corporation Improvement Act (FDICIA) of 1991, which introduced several nondiscretionary rules. In particular, the FDICIA required the FDIC to set risk-based premiums, whereby premiums differed according to three levels of bank capitalization (well capitalized, adequately capitalized, undercapitalized) and three supervisory rating groups (ratings of 1 or 2, a rating of 3, ratings of 4 or 5). However, the new rules have not been as effective as possible in differentiating between banks; indeed, from 1996 to 2006, more than 90 percent of all banks were categorized in the lowest risk category (well capitalized, with a rating of 1 or 2).

Furthermore, the FDICIA and the Deposit Insurance Act of 1996 specified that if DIF reserves exceed the 1.25 percent DRR, the FDIC is prohibited from charging insurance premiums to banks in the lowest risk category. During the 1996-2006 period, DIF reserves were above 1.25 percent of insured deposits and, because the majority of banks were classified in the lowest risk category, these banks did not pay for deposit insurance.

The Federal Deposit Insurance Reform Act of 2005 brought some changes to the setting of insurance premiums. In particular, the Act gave the DRR a range of 1.15 percent to 1.50 percent, instead of a hard target of 1.25 percent. When DIF reserves exceed 1.50 percent (1.35 percent), 100 percent (50 percent) of the surplus is rebated to banks. If DIF reserves fall below 1.15 percent, the FDIC must restore the fund and raise premiums to a level sufficient to return reserves to the DRR range within five years.

During the financial crisis of 2007-09, DIF reserves were hard-hit. The reserves fell to 1.01 percent of insured deposits on June, 30, 2008, and they decreased by $15.7 billion (45 percent) to $18.9 billion in the fourth quarter of 2008—plunging the reserve ratio to 0.4 percent of insured deposits, its lowest level since June 30, 1993.[5] In the first week of March 2009, the FDIC announced plans to charge 20 cents for every $100 of insured domestic deposits to restore the DIF.[6] On March 5, 2009, Sheila Bair, Chairperson of the FDIC, said that her agency would lower the charge to approximately 10 basis points if the FDIC's borrowing authority were increased.[7] Subsequently, U.S. senators Christopher Dodd and Michael Crapo introduced a bill that would permanently raise the FDIC's borrowing authority to $100 billion, from $30 billion, as well as temporarily allow the agency to borrow as much as $500 billion in consultation with the President and other regulators.

This short discussion confirms our earlier assertion that deposit insurance premiums have either been risk-insensitive or relied only on individual bank failure risk and never on systemic risk. Furthermore, even when premiums have been risk-sensitive, the focus has been on maintaining reserves at an "appropriate" level. For example, when the deposit insurance fund's reserves become sufficiently high relative to the size of insured deposits, the FDIC in effect returns premiums to banks. This type of approach to premiums is divorced from incentive properties. The rationale for charging banks a

[5] More recently, two additional failures have depleted the insurance fund further. On May 1, 2009, federal regulators shut down Silverton Bank, the fifth-largest bank to fail during the financial crisis of 2007-09. The FDIC estimates that the failure would cost the DIF $1.3 billion. On May 21, 2009, federal regulators seized BankUnited FSB, at an estimated cost of $4.9 billion to the DIF.

[6] "Bair: Without Fee, Fund May Go Dry." *American Banker*, March 5, 2009.

[7] "FDIC to Slash Special Fee." *American Banker*, March 6, 2009.

premium on a continual basis according to individual and systemic risk, regardless of the deposit insurance fund's size, is that it causes banks to internalize the costs of their failures on the fund and rest of the economy. Since a systemic crisis would most likely make the fund fall short and require the use of taxpayer funds, the incentive-efficient use of excess fund reserves is a return to taxpayers rather than to insured banks.

3. The Model

Our model is purposely simple. It is meant to illustrate the straightforward nature of our three results on the efficient design of premiums. In practice, quantifying systemic risk can be a challenge, but recent advances on this front (see, for instance, Adrian and Brunnermeier [2008] and Acharya et al. [2009]) present the opportunity to employ them in revisions of future deposit insurance schemes.

Our paper is related to the literature on the pricing of deposit insurance (Merton 1977, 1978; Marcus and Shaked 1984; McCulloch 1985; Ronn and Verma 1986; Pennacchi 1987a; Flannery 1991), the difficulty (Chan, Greenbaum, and Thakor 1992) and nondesirability (Freixas and Rochet 1998) of pricing deposit insurance fairly, deposit insurance and the degree of government regulatory control over banks (Pennacchi 1987b), and, more closely, deposit insurance pricing in the presence of regulatory forbearance in the closing of banks (Allen and Saunders 1993; Dreyfus, Saunders, and Allen 1994). However, our paper differs importantly from the literature cited, as our main purpose is to analyze the pricing of deposit insurance in a way that accounts for systemic risk as well as important features that contribute to systemic risk, such as correlation among banks' investments; the large size of some banks, which leads to fire-sale–related pecuniary externalities; and bank interconnectedness (also see Pennacchi [2006]).

We use the set-up in Acharya and Yorulmazer (2007). We consider an economy with three dates – $t = 0, 1, 2$, two banks – Bank *A* and Bank *B*, bank owners, depositors, outside investors, and a regulator. Each bank can borrow from a continuum of depositors of measure 1. Bank owners as well as depositors are risk-neutral, and obtain a time-additive utility w_t, where w_t is the expected wealth at time *t*. Depositors receive a unit of endowment at $t = 0$ and $t = 1$. Depositors also have access to a reservation investment opportunity that gives them a utility of 1 per unit of investment. In each period, that is, at date $t = 0$ and $t = 1$, depositors choose to invest in this reservation opportunity or in their bank.

Deposits take the form of a simple debt contract with a maturity of one period. In particular, the promised deposit rate is not contingent on investment decisions of the bank or on realized returns. In order to keep the model simple and yet capture the fact that there are limits to equity financing, we do not consider any bank financing other than deposits.

Banks require one unit of wealth to invest in a risky technology. The risky technology can be thought of as a portfolio of loans to firms in the corporate sector. The performance of the corporate sector determines its random output at date $t+1$. We assume that all firms in the sector can either repay fully the borrowed bank loans or they default on these loans. In the case of a default, we assume for simplicity that there is no repayment.

Suppose *R* is the promised return on a bank loan. We denote the random repayment on this loan as $\tilde{R}$, $\tilde{R} \in \{0, R\}$. The probability that the return from these loans is high (R) in period *t* is α_t:

$$\tilde{R} = \begin{cases} R \text{ with probability } \alpha_t \\ 0 \text{ with probability } 1 - \alpha_t. \end{cases} \quad (1)$$

We assume that the returns in the two periods are independent but allow the probability of high return to be different in the two periods. This helps isolate the effect of each probability on our results.

In addition to banks and depositors, there are outside investors who always have funds to purchase banking assets were these assets to be liquidated. However, outsiders do not have the skills to generate the full value from banking assets. To capture this, we assume that outsiders cannot generate *R* in the high state but only $(R - \Delta)$. Thus, when the banking assets are liquidated to outsiders, there may be a social welfare loss due to misallocation of these assets. We revisit this point in Section 5, when we investigate whether actuarially fair deposit insurance can prevent systemic risk.

The notion that outsiders may not be able to use banking assets as efficiently as the existing bank owners is akin to the notion of *asset-specificity*, first introduced in the corporate finance literature by Williamson (1988) and Shleifer and Vishny (1992). In summary, this literature suggests that firms whose assets tend to be *specific*, that is, whose assets cannot be readily redeployed by firms outside of the industry, are likely to experience lower liquidation values because they may suffer from fire-sale discounts in cash auctions for asset sales, especially when firms within an industry simultaneously become financially or economically distressed.[8] Regarding the evidence of such specificity for banks and financial institutions, James

[8]There is strong empirical support for this idea in the corporate finance literature, as shown, for example, by Pulvino (1998) for the airline industry and by Acharya, Bharath, and Srinivasan (2007) for the entire universe of defaulted firms in the United States from 1981 to 1999 (see also Berger, Ofek, and Swary [1996] and Stromberg [2000]).

(1991) studies the losses from bank failures in the United States from 1985 through mid-1988 and documents that "there is significant going concern value that is preserved if the failed bank is sold to another bank (a 'live bank' transaction) but is lost if the failed bank is liquidated by the FDIC."

In addition, our model includes the presence of a regulator. The deposits are fully insured by the regulator and the regulator charges deposit insurance premiums. Since deposits are fully insured, they are riskless. Hence, the rate of return on deposits is equal to the rate of return from the storage technology, that is, the deposit rate is equal to 1 in both periods. For simplicity, we assume that banks pay the insurance premiums using their retained earnings from earlier investments before $t = 0$.

If the return from the first-period investment is high, then the bank operates for one more period and makes the second-period investment.[9] For a bank to continue operating, it needs one unit to pay old deposits and an additional one unit to undertake the second-period investment, a total of two units. Since available deposits for a bank amount to only one unit (the endowment of its depositors), if the return from the first-period investment is low, then the bank is in default, it is closed, and its assets are sold (we discuss bailouts and recapitalization in Section 5).[10] We assume that if there is a surviving bank, then it has resources from its first-period profits to purchase the failed bank.

The possible states at date 1 are given as follows, where *S* indicates survival and *F* indicates failure:

SS: Both banks had the high return, and they operate in the second period.

SF: Bank *A* had the high return, while Bank *B* had the low return. Bank *B* is acquired by Bank *A*.

FS: This is the symmetric version of state *SF*.

FF: Both banks failed.

3.1 Correlation of Bank Returns

A crucial aspect of our model is that banks can choose the correlation of the returns from their investments by selecting the industries they invest in. At date 0, banks borrow deposits and then choose the composition of loans that compose their respective portfolios. This choice determines the level of correlation between the returns from their respective investments. We refer to this correlation as "interbank correlation."

Joint Probability of Bank Returns

		Same Industry		Different Industries	
		Bank B		Bank B	
		High (R)	*Low (0)*	*High (R)*	*Low (0)*
Bank A	*High (R)*	α_t	0	α_t^2	$\alpha_t(1-\alpha_t)$
	Low (0)	0	$1-\alpha_t$	$\alpha_t(1-\alpha_t)$	$(1-\alpha_t)^2$

Source: Authors' calculations.

Suppose there are two possible industries in which banks can invest, denoted as 1 and 2. Bank A (B) can lend to firms A_1 and A_2 (B_1 and B_2) in industries 1 and 2, respectively. If in equilibrium banks choose to lend to firms in the same industry, specifically they either lend to A_1 and B_1, or they lend to A_2 and B_2, then their returns are assumed to be perfectly correlated. However, if they choose different industries, then their returns are less than perfectly correlated, say, independent. When banks invest in the same industry, the correlation of banks' returns is $\rho = 1$, whereas when they invest in different industries, we have $\rho = 0$. This gives us the joint probability distribution of bank returns as presented in the table. Note that the individual probability of each bank succeeding or failing is constant (α_0 and $1-\alpha_0$, respectively), irrespective of the correlation in their returns.[11]

4. Actuarially Fair Insurance without Bailouts

In this section, we assume that the regulator sells the assets of the failed banks. (We analyze regulatory intervention in the form of recapitalization and bailouts in Section 5.)

Next, we show that the actuarially fair deposit insurance premium, the premium that is equal to the expected value of the payments from the insurance fund to the bank's depositors, depends on the correlation structure in banks' investments.

Since deposits are fully insured, the deposit rate in both periods is equal to 1.

In state *FF*, both banks fail, and sale to another bank is not an option. Thus, the failed banks' assets are sold to outsiders, which can also be thought of as the liquidation of the banks'

[9]For simplicity, we assume that the bank does not reinvest its profits from the first investment, for example, distribute them as dividends.

[10]In this model, the asset to be sold is the franchise value of the bank, that is, the expected future profit from the second-period investment the bank can take.

[11]Our results hold as long as the probabilities of states *SS* and *FF* are higher when banks invest in the same industry, rather than in different industries.

assets. Note that the outsiders cannot generate R from the banking assets but only $R - \Delta$. They are therefore willing to pay a price of at most $\underline{p}$ for the failed banks' assets where

$$p^{FF} = \underline{p} = \alpha_1(R - \Delta - 1). \quad (2)$$

We can think of $\underline{p}$ as the liquidation value of the bank.

In states *SF* or *FS*, the surviving bank can acquire the failed bank's assets. Note that a surviving bank can generate the full value of R from these assets. Thus, these assets are worth $\bar{p}$ for the surviving bank, where

$$\bar{p} = \alpha_1(R - 1). \quad (3)$$

Note that $\bar{p} > \underline{p}$. We assume that neither the regulator nor the surviving bank has the full bargaining power for the sale of the failed banks' assets. Thus, the price, denoted as p^{SF}, lies between $\underline{p}$ and $\bar{p}$, that is, $p^{SF} \in (\underline{p}, \bar{p})$.

When banks invest in the same industry with probability $(1 - \alpha_0)$, both banks fail and the proceeds from the sale of the failed banks' assets are equal to $p^{FF} = \underline{p}$. Let q_s be the insurance premium when banks invest in the same industry, where

$$q_s = (1 - \alpha_0)(1 - \underline{p}). \quad (4)$$

When banks invest in different industries, with probability $\alpha_0(1 - \alpha_0)$, only one bank fails and the proceeds from the sale are p^{SF}; with probability $(1 - \alpha_0)^2$, both banks fail and the proceeds from the sale of the failed banks' assets are equal to $p^{FF} = \underline{p}$. Let q_d be the insurance premium when banks invest in different industries, where

$$\begin{aligned} q_d &= \alpha_0(1 - \alpha_0)(1 - p^{SF}) + (1 - \alpha_0)^2(1 - \underline{p}) \\ &= q_s - \alpha_0(1 - \alpha_0)(p^{SF} - \underline{p}). \end{aligned} \quad (5)$$

Since the proceeds from the sale of failed banks' assets are lower when both banks fail, the loss to the insurance fund is higher when both banks fail. Thus, the actuarially fair insurance premiums should be higher when banks invest in the same industry, that is, $q_s > q_d$.

Result 1—(*Correlation and actuarially fair insurance premiums*): *The actuarially fair insurance premium depends on the correlation between banks' returns and should be higher when banks invest in the same industry, and is given as* $q_s = q_d + \alpha_0(1 - \alpha_0)(p^{SF} - \underline{p}) > q_d$.

Next, we show that the insurance premium should depend on bank size as well. Suppose that instead of two banks of equal size, we let Bank *A* be the large bank, with the size of depositors much larger than 1, while we keep the size of Bank *B* at 1.

We assume that if the regulator decides to liquidate the small bank, the large bank (or some other bank in the industry) has enough funds to purchase the small bank and can run it efficiently. Thus, assuming that all bargaining power does not lie with the regulator or the acquiring bank, when the small bank is liquidated the liquidation value is assumed to be $p_{small} \in (\underline{p}, \bar{p})$.

However, the size of Bank *A* is large enough so that the small bank cannot acquire and run the large bank efficiently. Thus, when the large bank is liquidated, it can be purchased only by outside investors and the price per unit of the large bank's assets is $p_{big} = \underline{p}$. Hence, the actuarially fair insurance premiums depend on the size of the bank. In particular, we obtain:

Result 2—(*Size and actuarially fair insurance premiums*): *The actuarially fair premium per dollar of insured deposits for the large bank is higher compared with that of the small bank and*

$$q_{small} = (1 - \alpha_0)(1 - p_{small}) < (1 - \alpha_0)(1 - \underline{p}) = q_{big}. \quad (6)$$

So far, we have restricted the actions of the regulator to the provision of deposit insurance and the resolution of bank failures only through sales. Since the failure of large banks or many banks at the same time can result in more adverse effects on the rest of the economy, it is more likely that, in such cases, regulators show forbearance or intervene in the form of bailouts or capital injections, resulting in fiscal costs. This, in turn, strengthens our argument that size and correlation should be an important component of insurance premiums. In the next section, we analyze insurance premiums in the presence of bailouts and recapitalizations, taking into account costs associated with the resolution of failed banks, such as the costs of liquidations and bailouts.

5. Resolution of Bank Failures and Insurance Premiums

In this section, we first analyze the problem of resolving bank failures when the regulator can bail out and recapitalize failed banks as well as sell the failed banks to a surviving bank (if any) or to outsiders. We show that in the case of a joint failure of banks, the regulator may prefer to bail out or recapitalize failed banks ex post ("too-many-to-fail" guarantees). However, such guarantees create incentives for banks to herd and make correlated investments, which makes the joint failure state—that is, the state of systemic crisis—more likely in the first place.

Next, we derive the *full-cost insurance premiums* that take into account all social costs of bank failures, including costs of inefficient liquidations and bailouts, and show that these premiums should be higher than the actuarially fair insurance

premiums derived in Section 4. Furthermore, we analyze how the regulator can use insurance premiums as a tool to minimize the occurrence of systemic crisis by preventing banks from choosing highly correlated investments. We use the term *incentive-efficient full-cost insurance premiums* to describe the premiums that take into account all social costs of bank failures while giving banks incentives to choose the low correlation.

5.1. Resolution of Bank Failures

Since there is no social welfare loss when assets remain in the banking system, the regulator has no incentive to intervene (in the form of bailouts) in states *SS*, *SF*, and *FS*. However, in state *FF*, the assets of failed banks can be purchased only by outside investors, resulting in misallocation costs. Hence, the regulator compares the welfare loss resulting from asset sales to outsiders with the cost of bailing out the failed banks. If it turns out that the welfare loss from inefficient liquidation is greater, then the regulator may decide to intervene in the form of bailouts and recapitalizations. The regulator's ex post decision is thus more involved in state *FF*, and we examine it fully. In order to analyze the regulator's decision to bail out or close failed banks, we make the following assumptions:

1) The regulator incurs a cost of $f(x)$ when it injects x units of funds into the banking sector. We assume that this cost function is increasing, $f' > 0$, and for simplicity we consider a linear cost function: $f(x) = ax, a > 0$. While we do not model this cost explicitly, we have in mind fiscal and opportunity costs to the regulator from providing funds with immediacy to the banking sector. Thus, if the regulator bails out only one bank (both banks), it incurs a bailout cost of a ($2a$).

The fiscal costs of providing funds to the banking sector with immediacy can be linked to a variety of sources, most notably: a) the distortionary effects of tax increases required to fund deposit insurance and bailouts and b) the likely effect of government deficits on the country's exchange rate, manifested in the fact that banking crises and currency crises have often occurred as "twins" in many (especially emerging market) countries. Ultimately, the fiscal cost we have in mind is one of immediacy: Government expenditures and inflows during the regular course of events are smooth, relative to the potentially rapid growth of "off-balance-sheet contingent liabilities," such as the costs of bank bailouts.[12]

2) If the regulator decides not to bail out a failed bank, the existing depositors are paid back through deposit insurance and the failed bank's assets are sold to outsiders. The crucial difference between bailouts and asset sales from an ex post standpoint is that proceeds from asset sales lower the fiscal cost from the immediate provision of deposit insurance, whereas bailouts produce no such proceeds. In other words, bailouts entail an opportunity cost to the regulator in fiscal terms.

Under these assumptions, the regulator's resolution policy can be characterized as follows. The regulator's objective in state *FF* is to maximize the total expected output of the banking sector net of any bailout or liquidation costs. We denote this as $E(\Pi_2^{ff})$. Thus, if both banks are closed, the regulator's objective function takes the value

$$E(\Pi_2^{ff}) = 2[\alpha_1(R-\Delta) - 1], \tag{7}$$

which is the liquidation value of banking assets to outsiders. This equals $[2(\alpha_1 R - 1) - 2\alpha_1\Delta]$, the difference between the banking sector output in each of the states *SS*, *SF*, and *FS*, minus the liquidation costs from closing both banks.

If both banks are bailed out, then the regulator's objective function takes the value

$$E(\Pi_2^{ff}) = 2(\alpha_1 R - 1) - f(2), \tag{8}$$

as the bailout costs are now based on the total amount of funds, 2, injected into the banking sector with immediacy.[13]

Comparing these objective-function evaluations, we obtain the following resolution policy for the regulator in state *FF*. It has the intuitive property that if liquidation costs ($\alpha_1\Delta$) are sufficiently high and/or the costs of bailouts ($f(.)$) are not too steep, then there are "too many (banks) to fail" and the regulator prefers to rescue failed banks.

Resolution: *When both banks fail (state FF), the regulator takes the following actions:*

- *If* $\alpha_1\Delta \le f(1)$, *then both banks' assets are sold to outsiders.*
- *If* $\alpha_1\Delta > f(1)$, *then the regulator bails out both banks.*

[12] See, for example, the discussion of fiscal costs associated with banking collapses and bailouts in Calomiris (1998). Hoggarth, Reis, and Saporta (2002) find that the cumulative output losses have amounted to a sizable 15 percent to 20 percent of annual GDP in the banking crises of the past twenty-five years. Caprio and Klingebiel (1996) argue that the bailout of the thrift industry cost $180 billion (3.2 percent of GDP) in the United States in the late 1980s. They also document that the estimated cost of bailouts was 16.8 percent for Spain, 6.4 percent for Sweden, and 8 percent for Finland. Honohan and Klingebiel (2000) find that countries spent 12.8 percent of their GDP to fix their banking systems, whereas Claessens, Djankov, and Klingebiel (1999) set the cost at 15 percent to 50 percent of GDP. Also see Panageas (2009) for an analysis of the optimal financing of government interventions.

[13] With the linear fiscal cost function $f(.)$, the regulator either bails out both banks or liquidates both. With a strictly convex fiscal cost function $f(.)$, there may be cases in which it is optimal to bail out one bank and liquidate the other, since the marginal cost of bailouts increases as more banks are bailed out. See Acharya and Yorulmazer (2007) for a discussion.

Thus, the expected second-period profits of the bank depend on the regulator's decision:

$$(9) \qquad E(\pi_2^{ff}) = \begin{cases} 0 \text{ if } \alpha_1 \Delta \le f(1) \\ \bar{p} \text{ if } \alpha_1 \Delta > f(1) \end{cases}.$$

Note that in either case, in state *FF* there is a social welfare loss resulting from bailout or liquidation, whereas no such cost arises in states *SF* or *FS*. Thus, the socially optimal outcome is achieved when the probability of state *FF* is at a minimum, that is, when banks invest in different industries.

5.2. Systemic Risk and Insurance Premiums

First, we derive the *full-cost insurance premiums*—the premiums that take into account all social costs of bank failures including costs of liquidations and bailouts. Note that the actuarially fair insurance premiums in Section 4 take into account only the expected payments to depositors; thus, they fail to account for the social costs of bank failures, such as costs of liquidations and bailouts.

We can show that the full-cost insurance premiums $\tilde{q}_s$ and $\tilde{q}_d$ when banks invest in the same industry and in different industries, respectively, are given as:

$$(10) \quad \tilde{q}_s = (1-\alpha_0)[(1-\underline{p}) + min\{\alpha_1\Delta, f(1)\}] > q_s, \text{ and}$$

$$(11) \qquad \tilde{q}_d = \alpha_0(1-\alpha_0)(1-p^{SF}) + (1-\alpha_0)^2[(1-\underline{p}) + min\{\alpha_1\Delta, f(1)\}] > q_d.$$

We can obtain the relationship between these insurance premiums as follows:

$$(12) \quad \tilde{q}_s = \tilde{q}_d + \alpha_0(1-\alpha_0)[(p^{SF} - \underline{p}) + min\{\alpha_1\Delta, f(1)\}] > \tilde{q}_d.$$

As in the case of actuarially fair insurance premiums, the loss to the regulator through the insurance fund is higher when both banks fail. Furthermore, the joint failure state is always associated with social costs, such as costs from inefficient liquidations or bailouts, whereas these costs can be avoided in the individual failure states. Thus, the full-cost insurance premiums are higher than the actuarially fair insurance premiums, that is, $\tilde{q}_s > q_s$ and $\tilde{q}_d > q_d$. Furthermore, the wedge between the insurance premiums $\tilde{q}_s$ and $\tilde{q}_d$ is higher compared with the corresponding wedge for the actuarially fair insurance premiums, that is, $\tilde{q}_s - \tilde{q}_d > q_s - q_d$.

Next, we investigate banks' choice of correlation in their investments and find the *incentive-efficient insurance premiums* $\hat{q}_s$ and $\hat{q}_d$ that induce banks to choose the low correlation. Also, we combine our results with those of the previous discussion to find the *incentive-efficient full-cost insurance premiums* that take into account all costs associated with the resolution of failed banks while incentivizing banks to choose the low correlation.

In the first period, both banks are identical. Hence, we consider a representative bank. Formally, the objective of each bank is to choose the level of interbank correlation ρ at date 0 that maximizes

$$(13) \qquad E(\pi_1(\rho)) + E(\pi_2(\rho)),$$

where discounting has been ignored since it does not affect any of the results. Recall that if banks invest in different industries, then interbank correlation ρ equals 0, or else it equals 1.

Note that when banks invest in the same industry, $\Pr(SF) = 0$, so that

$$(14) \qquad E(\pi_2(1)) = \alpha_0 E(\pi_2^{ss}) + (1-\alpha_0)E(\pi_2^{ff}) - \hat{q}_s.$$

When banks invest in different industries, we obtain that

$$(15) \qquad E(\pi_2(0)) = \alpha_0^2 E(\pi_2^{ss}) + \alpha_0(1-\alpha_0)E(\pi_2^{sf}) + (1-\alpha_0)^2 E(\pi_2^{ff}) - \hat{q}_d.$$

We know that $E(\pi_2^{sf}) = E(\pi_2^{ss}) + (\bar{p} - p^{SF})$. Thus, we can write

$$(16) \qquad E(\pi_2(0)) = \alpha_0 E(\pi_2^{ss}) + \alpha_0(1-\alpha_0)(\bar{p} - p^{SF}) + (1-\alpha_0)^2 E(\pi_2^{ff}) - \hat{q}_d,$$

which gives us

$$(17) \quad E(\pi_2(1)) - E(\pi_2(0)) = \alpha_0(1-\alpha_0)[E(\pi_2^{ff}) - (\bar{p} - p^{SF})] + \hat{q}_d - \hat{q}_s.$$

Hence, the only terms that affect the choice of interbank correlation are the subsidy that failed banks receive $(E(\pi_2^{ff}))$ from a bailout in state *FF*, the discount the surviving bank receives in state *SF* from acquiring the failed bank's assets, and the deposit insurance premiums $\hat{q}_s$ and $\hat{q}_d$. Therefore, for banks to choose the low correlation, the premium charged when banks invest in the same industry has to be at least:

$$(18) \qquad \hat{q}_s = \alpha_0(1-\alpha_0)[E(\pi_2^{ff}) - (\bar{p} - p^{SF})] + \hat{q}_d.$$

Note that when the regulator chooses to liquidate the failed bank, rather than bail it out, there is no bailout subsidy and the full-cost insurance premiums $\tilde{q}_s$ and $\tilde{q}_d$ are at the same time incentive-efficient, that is, they induce banks to choose the low correlation. However, when the regulator bails out failed banks, the subsidy from the bailout creates a wedge between the incentive-efficient premium $\hat{q}_s$ and the full-cost insurance premium $\tilde{q}_s$. Combining this with our previous result on the insurance premium, we obtain the *incentive-efficient full-cost*

premiums as $\tilde{q}_d$ when banks invest in different industries and $\bar{q}_s = \max\{\tilde{q}_s, \hat{q}_s\}$ when banks invest in the same industry. When the regulator charges the premiums $(\bar{q}_s, \tilde{q}_d)$, banks choose the low correlation (incentive-efficient) and pay for the entire expected costs associated with their failure, including the costs of inefficient liquidations and bailouts. We obtain the following result:

Result 3—(*Incentive-efficient full-cost premiums*): *The insurance premiums that induce banks to choose the low correlation and that cover all expected costs associated with bank failures are* $\tilde{q}_d$ *and* $\bar{q}_s = \max\{\tilde{q}_s, \hat{q}_s\}$ *when banks invest in different industries and the same industry, respectively. Furthermore, we obtain* $\tilde{q}_s > q_s$ *and* $\tilde{q}_d > q_d$, *and the wedge between the insurance premiums* $\bar{q}_s$ *and* $\tilde{q}_d$ *is higher compared with the corresponding wedge for the actuarially fair insurance premiums, that is,* $\bar{q}_s - \tilde{q}_d > q_s - q_d$.

Note that the insurance premiums with regulatory intervention in the form of bailouts are different from the ones without such regulatory intervention. Given that the regulator may not be credible in closing banks during systemic crises, which creates incentives for banks to invest in the same industry ex ante, deposit insurance premiums may act as a tool to alleviate the time-inconsistency problem inherent in the regulator's policy.

We observe government bailouts during banking crises, more so when a crisis is systemic. Thus, banks may have private benefits from choosing correlated investments such as possible bailouts. In those cases, the actuarially fair premium (which may no longer be fair from a social welfare point of view) may not be enough to prevent banks from choosing highly correlated investments. If we believe that the social costs of bank failures (either misallocation costs due to liquidation and destruction of value, or costs of bailouts) increase in a convex fashion as the number of failures increases, then the regulator would like to prevent states in which many banks fail, that is, the regulator would like to prevent banks from being overexposed to common risk factors. In those cases, the actuarially fair premium may not prevent banks from investing in the same industry, that is, it may not prevent systemic bank failures. Thus, for the regulator to prevent systemic risk, all costs of failures should be priced in, and the premium imposed when banks invest in the same industry should be higher.

The practical design of regulatory tools to address important contributors to systemic risk, such as correlation and size, can be difficult and potentially costly from a political point of view. An alternative way to address these issues is through the use of closure rules. One possibility, as Acharya and Yorulmazer (2008) argue, is to use taxpayer funds, not to guarantee bank debt, but to make transfers to healthier institutions and enable the institutions to acquire failed banks at higher costs than they would using only private funds. Such mechanisms, however, have their limits, as larger banks emerge from crisis resolution and closure rules are generally negatively affected by time-inconsistency problems.

6. Conclusion

This paper has shown that the efficient setting of deposit insurance premiums would be most effective if it took into account systemic risk, which justifies the existence of such insurance in the first place. Some of the major factors that lead to systemic risk are correlation among banks' returns, bank size, and bank interconnectedness. These factors need to be explicitly and continually considered when setting deposit insurance premiums.

Our focus has been on the pricing of deposit insurance. Although the same principles apply to the design of other regulatory tools, such as capital and liquidity requirements (Acharya 2009), an interesting question is the effectiveness of different regulatory rules in addressing different sources of systemic risk.[14] Systemic risk is a negative externality arising from one financial institution's failure on other institutions and the economy; it entails significant welfare costs when it materializes in the form of widespread failures. Regulation is required to maintain efficient levels of systemic risk—much like pollution is regulated through the imposition of certain taxes. However, such regulation will be effective only if it is tied to the extent of systemic risk.

[14]Sharpe (1978) shows that in the absence of moral hazard and information frictions, there is an isomorphism between risk-based insurance premiums and risk-related capital standards. Flannery (1991), however, shows that when there is asymmetry of information, this isomorphism no longer holds.

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John Geanakoplos

Solving the Present Crisis and Managing the Leverage Cycle

1. Introduction

The present crisis is the bottom of a leverage cycle. Understanding that tells us what to do, in what order, and with what sense of urgency. Public authorities have acted aggressively, but because their actions were not rooted in (or explained with reference to) a solid understanding of the causes of our present distress, we have started in the wrong place and paid insufficient attention and devoted insufficient resources to matters—most notably, the still-growing tidal wave of foreclosures and the sudden deleveraging of the financial system—that should have been first on the agenda.

In short and simple terms, by leverage cycle I mean this. There are times when leverage is so high that people and institutions can buy many assets with very little money down and times when leverage is so low that buyers must have all or nearly all of the money in hand to purchase those very same assets. When leverage is loose, asset prices go up because buyers can get easy credit and spend more. Similarly, when leverage is highly constrained, that is, when credit is very difficult to obtain, prices plummet. This is what happened in real estate and what happened in the financial markets. Governments have long monitored and adjusted interest rates in an attempt to ensure that credit did not freeze up and thereby threaten the economic stability of a nation. However, leverage (equivalently, collateral rates) must also be monitored and adjusted if we are to avoid the destruction that the tail end of an outsized leverage cycle can bring.

Economists and the public have often spoken of tight credit markets, meaning something more than high interest rates, but without precisely specifying or quantifying exactly what they meant. A decade ago, I showed that the collateral rate, or leverage, is an *equilibrium* variable distinct from the interest rate.[1] The collateral rate is the value of collateral that must be pledged to guarantee one dollar of loan. Today, many businesses and ordinary people are willing to agree to pay bank interest rates, but they cannot get loans because they do not have the collateral to put down to convince the banks their loan will be safe.

Huge moves in collateral rates, which I have called "the leverage cycle," are a recurring phenomenon in American financial history.[2] The steps we must take at the end of the current cycle emerge from understanding what makes a leverage cycle swing up, sometimes to dizzying extremes, and then come crashing down, often with devastating consequences.

[1] Geanakoplos (1997, 2003).

[2] The history of leverage is still being written, because until recently it was not a variable that was explicitly monitored. But work by Adrian and Shin (forthcoming) and others is helping to restore the historical record.

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On October 3, 2008, the author presented to Ben Bernanke and the Federal Reserve Board of Governors the substance of this paper's proposal. The author is grateful to Susan Koniak for very helpful and detailed comments and advice, as well as for allowing him to use material from their two *New York Times* editorials. He is also appreciative of the very fine comments received from Asani Sarkar and two referees, and is deeply indebted to Joseph Tracy for editorial advice far beyond the call of duty, encompassing tone, style, and content. Needless to say, neither he nor anyone else is responsible for, or even necessarily in agreement with, the views expressed here. The views expressed are those of the author and do not necessarily reflect the position of the Federal Reserve Bank of New York or the Federal Reserve System.

All leverage cycles end with: 1) bad news that creates uncertainty and disagreement, 2) sharply increasing collateral rates, and 3) losses and bankruptcies among the leveraged optimists. These three factors reinforce and feed back on each other. In particular, what begins as uncertainty about exogenous events creates uncertainty about endogenous events, like how far prices will fall or who will go bankrupt, which leads to further tightening of collateral, and thus further price declines and so on. In the aftermath of the crisis, we always see depressed asset prices, reduced economic activity, and a collection of agents that are not yet bankrupt but hovering near insolvency. How long the aftermath persists depends on how deep the crisis was and how effective government intervention is.

Once the crisis has started, the thematic solution is to reverse the three symptoms of the crisis: contain the bad news, intervene to bring down margins, and carefully inject "optimistic" equity back into the system. As with most difficult problems, a multi-pronged approach is generally the most successful. To be successful, any government plan must respect all three remedial prongs, and their order. The unusual government interventions in this cycle have in many respects been quite successful in averting a disaster—precisely, I would argue, because they embodied some of the novel leverage cycle principles I describe here. The effectiveness of the interventions could be increased even further by respecting the priorities of the problem.

In what follows, I explain what happens in the leverage cycle and why it is so bad for the economy that it must be monitored and controlled by the government. I show how this last cycle fits the pattern and I further explain why this leverage cycle is worse than all the others since the Depression. I point out that the now-famous counterparty risk problem, which has received so much attention of late, is also a matter of collateral. Next, I present details on how to intervene to pull out of a leverage cycle crisis like the one we are passing through now; this discussion is divided into three sections, corresponding to the three symptoms of every leverage cycle crisis. I advocate a permanent lending facility that will stand ready, should another crisis arise, to give loans with less collateral than the market demands. In another section, I suggest that principal reduction (partial debt forgiveness) by private lenders is a key tool in dealing with the many agents, like homeowners today, that fall underwater at the bottom of a deep leverage crisis. In the third section, I assemble the many pitfalls the government must be watchful of if it feels obliged to rescue drowning firms or it is tempted to buy assets at "fire-sale" prices in the darkest days of the crisis. I conclude with a list of recommendations for managing the leverage cycle in its ebullient period that might prevent the next cycle from reaching such a devastating crisis stage.

2. Margins, the Leverage Cycle, and Asset Prices

Traditionally, governments, economists, as well as the general public and the press, have regarded the interest rate as the most important policy variable in the economy. Whenever the economy slows, the press clamors for lower interest rates from the Federal Reserve, and the Fed often obliges. But sometimes, especially in times of crisis, collateral rates (equivalently, margins or leverage) are far more important than interest rates. The Fed could be managing collateral rates all through the leverage cycle, but especially in the ebullient and the crisis stages.

The use of collateral and leverage is widespread. A homeowner (or a big investment bank or hedge fund) can often spend $20 of his own cash to buy an asset like a house for $100 by taking out a loan for the remaining $80 using the house as collateral. In that case, we say that the margin or haircut or down payment is 20 percent, the loan to value is $80/$100 = 80 percent, and the collateral rate is $100/$80 or 125 percent. The leverage is the reciprocal of the margin, namely, the ratio of the asset value to the cash needed to purchase it, or $100/$20 = 5. All of these *ratios* are different ways of saying the same thing.

In standard economic theory, the equilibrium of supply and demand determines the interest rate on loans. But in real life, when somebody takes out a secured loan, he must negotiate two things: the interest rate and the collateral rate. A proper theory of economic equilibrium must explain both. Standard economic theory has not really come to grips with this problem for the simple reason that it seems intractable: how can one supply-equals-demand equation for a loan determine two variables—the interest rate and the collateral rate? There is not enough space to explain the resolution of this puzzle here, but suffice it to say that ten years ago I showed that supply and demand do indeed determine both. Moreover, the two variables are influenced in the equilibration of supply and demand mainly by two different factors: the interest rate reflects the underlying impatience of borrowers, and the collateral rate reflects the perceived volatility of asset prices and the resulting uncertainty of lenders.[3] Another factor influencing leverage in the long run is the degree of financial innovation. Since scarce collateral is often an important limiting factor, the economy will gradually devise ways of stretching the collateral, by tranching (so the same collateral backs several loans) and pyramiding loans (so the same

[3] In Geanakoplos (1997), I show how supply and demand can indeed simultaneously determine the interest rate and the collateral rate. In Geanakoplos (2003), I show how intertemporal changes in volatility lead to changes in the equilibrium leverage over time as part of what I call a leverage cycle. In Geanakoplos (1997) and Geanakoplos and Zame (2009), I emphasize the scarcity of collateral and the role of tranching and pyramiding.

collateral can be used over and over to back loans backed by loans).

Practitioners, if not economists, have long recognized the importance of collateral and leverage. For a Wall Street trader, leverage is important for two reasons. The first is that if he is leveraged λ times, then a 1 percent change in the value of the collateral means a λ percent change in the value of his capital. (If the house in our example goes from $100 to $101, then after selling the house at $101 and repaying the $80 loan, the investor is left with $21 of cash on his $20 investment, a 5 percent return.) Leverage thus makes returns riskier, either for better or for worse. Second, a borrower knows that if there is no-recourse collateral, so that he can walk away from his loan after giving up the collateral without further penalty, then his downside is limited. The most the borrower can lose on the house loan is his $20 of cash, even if the house falls in value all the way to $0 and the lender loses $80. No-recourse collateral thus effectively gives the borrower a put option (to "sell" the house for the loan amount). Recently, several commentators have linked leverage to the crisis, arguing that if banks were not so leveraged in their borrowing they would not have lost so much money when prices went down, and that if homeowners were not so leveraged, they would not be so far underwater now and so tempted to exercise their put option by walking away from their house. Of course, these two points are central to my own leverage cycle theory; I discuss them in more detail later. But there is another, deeper point to my theory that has so far not received as much attention, which I think is the real story of leverage.

The main implication of my leverage cycle theory is that when leverage goes up, asset prices go up, and when leverage goes down, asset prices go down.[4] For many assets, there is a class of natural buyers or optimists who are willing to pay much more for the asset than the rest of the public. They may be more risk-tolerant. Or they may simply be more optimistic. Or they may like the collateral (for example, housing) more.[5] If they can get their hands on more money through borrowing, they will spend it on the assets and drive those asset prices up. If they lose wealth, or lose the ability to borrow, they will be able to buy less of the asset, and the asset will fall into more pessimistic hands and be valued less.

It is useful to think of the potential investors arrayed on a vertical continuum, in descending order according to their willingness to buy, with the most enthusiastic buyers at the top (see exhibit). Whatever the price, those at the top of the continuum above a threshold will value the asset more and become buyers, while those below will value it less and sell. The marginal buyer is the agent at the threshold on the cusp of selling or buying and it is his opinion that determines the price. The higher the leverage, the smaller the number of buyers at the top required to purchase all the available assets. As a result, the marginal buyer will be higher in the continuum and therefore the price will be higher.

Natural Buyers Theory of Price

It is well known that a reduction in interest rates will increase the prices of assets such as houses. It is less appreciated, but more obviously true, that a reduction in margins will raise asset prices. Conversely, if margins go up, asset prices will fall. A potential homeowner who in 2006 could buy a house by putting 3 percent cash down might find it unaffordable to buy now that he has to put 30 percent cash down, even if the Fed managed to reduce mortgage interest rates by 1 percent or 2 percent. This has diminished the demand for housing, and therefore housing prices. What applies to housing applies much more to the esoteric assets traded on Wall Street (such as mortgage-backed investments), where the margins (that is, leverage) can vary much more radically. In 2006, the $2.5 trillion of so-called toxic mortgage securities could be bought by putting $150 billion down and borrowing the other $2.35 trillion.[6] In early 2009, those same securities might collectively have been worth half as much, yet a buyer might have had to put nearly the whole amount down in cash. In Section 3.1, I illustrate the connection between leverage and asset prices over the current cycle.

Economists and the Federal Reserve ask themselves every day whether the economy is picking the right interest rates. But one can also ask the question whether the economy is picking the right equilibrium margins. At both ends of the leverage cycle, it does not. In ebullient times, the equilibrium collateral rate is too loose; that is, equilibrium leverage is too high. In bad times, equilibrium leverage is too low. As a result, in ebullient times asset prices are too high, and in crisis times they plummet too low. This is the leverage cycle.

[4] Leverage is like more money in making prices go up, but, unlike money, it affects only prices of goods that can serve as collateral; printing more money tends to increase all prices, including those of food and other perishables.

[5] Two additional sources of heterogeneity are that some investors are more expert at hedging assets, and that some investors can more easily obtain the information (like loan-level data) and expertise needed to evaluate the assets.

[6] This number is calculated by applying the bank regulatory capital requirement (based on bond credit rating) to each security in 2006 at its 2006 credit rating.

The policy implication of the leverage cycle is that the Fed could manage systemwide leverage, seeking to maintain it within reasonable limits in normal times, stepping in to curtail it in times of ebullience, and propping it up as market actors become anxious, and especially in a crisis. To carry out this task, of course, the Fed must first monitor leverage. The Fed must collect data from a broad spectrum of investors, including hitherto secretive hedge funds, on how much leverage is being used to buy various classes of assets. Moreover, the amount of leverage being employed must be transparent. The accounting and legal rules that govern devices, such as structured investment vehicles, that were used to mask leverage levels must be reformed to ensure that leverage levels can be more readily and reliably discerned by the market and regulators alike. As we shall see, the best way to monitor leverage is to do it at the *security* level by keeping track of haircuts on all the different kinds of assets used as collateral, including in the repo market and in the housing market. Also very useful, but less important, is monitoring the *investor* leverage (or the debt-equity ratio) of big firms.

The leverage cycle is no accident, but a self-reinforcing dynamic. Declining margins, or, equivalently, increasing leverage, are a consequence of the happy coincidence of universal good news and the absence of danger on the horizon. With markets stable and the horizon looking clear, lenders are happy to reduce margins and provide more cash. Good, safe news events by themselves tend to make asset prices rise. But they also encourage declining margins, which in turn cause the massive borrowing that inflates asset prices still more.

Similarly, when the news is bad, asset prices tend to fall on the news alone. But the prices often fall further if the margins are tightened. Sudden and dramatic increases in margins are relatively rare. They seem to happen once or twice a decade. Bad news arrives much more often than that, so it is not bad or even very bad news alone that drastically raises margins. Bad news lowers expectations, and, like all news, usually clarifies the situation.

Every now and then, bad news, instead of clarifying matters, increases uncertainty and disagreement about the future. It is this particular kind of "scary bad" news that increases margins. For example, when an airline announces the plane will be ten minutes late, the passengers start to worry the delay might be an hour. When a bank announces a $5 billion loss, investors worry that more losses might be on the way. In 2006, people disagreed about whether losses from defaults on prime mortgages would be 1/4 percent or 1/2 percent, and whether losses on subprime mortgages would be 1 percent or 5 percent. By contrast, after the scary news of 2007, people disagreed about whether some subprime losses would be 30 percent or 80 percent. Even from their low, many lenders were afraid many assets could lose even more value, maybe all their value. The present became worse, and the future more uncertain.

The upshot of increased uncertainty and disagreement is that margins go up drastically. Lenders are typically more pessimistic than buyers. Otherwise, they too would be buying, instead of lending. Even if the optimists are not worried much about more losses, the lenders are, and they will demand high margins. When the lenders are worried about 80 percent losses from current levels, they will lend only if margins are at least 90 percent, or not lend at all.

As we have just witnessed, the rapid increase in margins always comes at the worst possible time. Buyers who were allowed to massively leverage their purchases with borrowed money are forced to sell when bad news drives asset prices lower. But when margins rise dramatically, more modestly leveraged buyers are also forced to sell. Tightening margins turn willing buyers into forced sellers, driving prices further down. We enter the crisis stage I discuss below.

The dynamic of the leverage cycle cannot be stopped by a tongue lashing of greedy Wall Street investors or overly ambitious homeowners in the ebullient stage of the cycle, nor by exhortations not to panic in the crisis stage. The cycle emerges even if (in fact, precisely because) every agent is acting rationally from his individual point of view. It is analogous to a prisoner's dilemma, where individual rationality leads to collective disaster. The government must intervene.

The intervention becomes all the more necessary if agents are irrationally exuberant and then irrationally panicked, or are prone to short-sighted greed, or to the "keeping up with the Jones" syndrome. If greedy investors want higher expected returns, no matter what the risk, competition will force even conservative fund managers to leverage more. For example, an investor comes to a hedge fund and says, "the fund down the block is getting higher returns." The fund manager counters that the competitor is just using more leverage. The investor responds, "well whatever he's doing, he's getting higher returns." Pretty soon, both funds are leveraging more. Housing prices can rise in the same way. When some families borrow a lot of money to buy their houses, housing prices rise and even conservative homeowners are forced to borrow and leverage so they too can live in comparable houses, if keeping up with their peers is important to them. At the bottom end, nervous investors might withdraw their money, forcing hedge fund managers to sell just when they think the opportunities are greatest. However, of all the irrationalities that exacerbated this leverage cycle, I would not point to these or to homeowners who took out loans they could not really afford, but rather to lenders who underestimated the put option and failed to ask for enough collateral.

The observation that collateral rates are even more important outcomes of supply and demand than interest rates, and even more in need of regulation, was made over 400 years

ago. In *The Merchant of Venice*, Shakespeare depicted accurately how lending works: one has to negotiate not just an interest rate but the collateral level too. And it is clear which of the two Shakespeare thought was the more important. Who can remember the interest rate Shylock charged Antonio? But everybody remembers the "pound of flesh" that Shylock and Antonio agreed on as collateral. The upshot of the play, moreover, is that the regulatory authority (the court) intervenes and decrees a new collateral level—very different from what Shylock and Antonio had freely contracted—"a pound of flesh, but not a drop of blood." The Fed, too, could sometimes decree different collateral levels (before the fact, not after, as in Shakespeare).

The modern study of collateral seems to have begun with Kiyotaki and Moore (1997), Bernanke, Gertler, and Gilchrist (1996, 1999), Holmstrom and Tirole (1997), Geanakoplos (1997, 2003), and Geanakoplos and Zame (2009).[7] Bernanke, Gertler, and Gilchrist and Holmstrom and Tirole emphasize the asymmetric information between borrowers and lenders as the source of limits on borrowing. For example, Holmstrom and Tirole argue that the managers of a firm would not be able to borrow all the inputs necessary to build a project, because lenders would like to see them bear risk, by putting their own money down, to guarantee that they exert maximal effort. Kiyotaki and Moore (1997) and Geanakoplos (1997) study the case where the collateral is an asset such as a mortgage security, where the buyer/borrower using the asset as collateral has no role in managing the asset, and asymmetric information is therefore not important. The key difference between Kiyotaki and Moore and Geanakoplos (1997) is that in Kiyotaki and Moore, there is no uncertainty, and so the issue of leverage as a ratio of loan to value does not play a central role; to the extent it does vary, leverage in Kiyotaki and Moore goes in the wrong direction, getting higher after bad news, and dampening the cycle. In Geanakoplos (1997, 2003), I introduce uncertainty and solve for equilibrium leverage and equilibrium default rates; I show how leverage could be determined by supply and demand, and how under some conditions, volatility (or more precisely, the tail of the asset return distribution) pins down leverage. In Geanakoplos (2003), I introduce the leverage cycle in which changes in the volatility of news lead to changes in leverage, which in turn lead to changes in asset prices. This line of research has been pursued by Gromb and Vayanos (2002), Fostel and Geanakoplos (2008), Brunnermeier and Pedersen (2009), and Adrian and Shin (forthcoming), among others.

[7] Minsky (1986) was a modern pioneer in calling attention to the dangers of leverage. But to the best of my knowledge, he did not provide a model or formal theory. Tobin and Golub (1998) devote a few pages to leverage and the beginnings of a model.

2.1 Investor Heterogeneity, Equilibrium Leverage, Default, and Maturity

Without heterogeneity among investors, there would be no borrowers and lenders, and asset prices would not depend on the amount of leverage in the economy. It is interesting to observe that the kind of heterogeneity influences the amount of equilibrium leverage, and hence equilibrium asset prices, and equilibrium default.

When investors differ only in their optimism about future events in a one-dimensional manner, then the equilibrium leverage will consist of the maximum promise that does not permit default.[8] For example, suppose an asset will be worth either 1 or .2 next period. Suppose further that risk-neutral investors differ only in the probability h that they assign to the outcome being 1. The most optimistic investor $h = 1$ is sure that the asset will be worth 1, and the most pessimistic investor $h = 0$ is sure the asset will be worth .2. At any asset price p, the investors with h big enough that $h*1 + (1-h)*(.2) > p$ will want to buy the asset, while the rest will want to sell the asset. The buyers with high h will want to borrow money in order to get their hands on what they regard as cheap assets, while the sellers with low h will not need the money and so will be willing to lend. How much will the borrowers be able to promise using the asset as collateral, assuming the promise is not contingent on the state? The answer is .2, precisely the maximum promise that does not lead to default in either state.[9]

Thus, when the heterogeneity stems entirely from one-dimensional differences in opinion, equilibrium leverage entails no default. A consequence of this is that the loans will be very short term. The longer the maturity of the loan, the more that can go wrong in the meantime, and therefore the smaller the loan amount can be if it avoids any chance of default. Investors who want to borrow large amounts of money will be driven to borrow very short term. The repo market displays these characteristics of short, one-day loans, on which there is almost never any default, even in the worst of crises.

Much the same analysis holds when investors differ only in their risk aversion. For the most risk-averse investors, an asset that pays 1 or .2 will be regarded as too dangerous, while

[8] See Geanakoplos (2003).

[9] At first glance, it would seem that the most optimistic buyers might be willing to promise, say, .3 in both states, in order to get more money today to invest in a sure winner of an asset. But since this promise will deliver .3 in the good state but only .2 in the bad state (assuming no-recourse collateral), the lenders will not want to pay much for this debt: this risky debt is very much like the asset they do not want to hold, and so they will pay very little more for it than the (.2,.2) promise, where (g,b) denotes a payoff of g if the good state occurs and b if the bad state occurs. Since the borrowers would have to give up .3 > .2 in the state they think is likely to occur, they will choose to use their scarce collateral to back the (.2,.2) promise instead of the (.3,.3) promise.

investors with greater risk tolerance will find it attractive at the right price. These risk-tolerant investors will leverage their purchases, by borrowing money to buy the asset, using it as collateral for their loan. Once again, the equilibrium leverage will rise to the point that the promises made will be (.2,.2) but no more (see footnote 9 for an explanation of notation). To be more concrete, suppose contrary to the previous case, that all the agents regard the outcomes 1 and .2 as equally likely. But suppose that untraded endowments rise and fall together with the asset payoffs. Then risk-averse agents on the margin will regard an extra penny when the asset pays 1 as less valuable than an extra penny when the asset pays .2; on the margin, they would prefer a penny when the asset pays .2. Hence, they will behave as if they regarded the payoff of 1 as less likely, exactly the same way the pessimists behaved, despite having the same beliefs as the risk-tolerant agents. Equilibrium leverage with heterogeneous risk aversion becomes the same as with heterogeneous beliefs.

The situation changes when some investors simply like owning the asset for its own sake in the period they buy it, such as when a homeowner likes living in the house. A similar situation arises if a producer can get more output from the asset than can be recovered if the lender takes it over. Somewhat surprisingly, in these cases the equilibrium leverage might be to promise (1,1) even when the asset will only deliver (1,.2) with probabilities everyone agrees on. If there are multiple states, and a cost of seizing the collateral, then the equilibrium promise will be somewhere between the maximum and minimum delivery. Contrary to the previous two cases, equilibrium leverage will involve a distinctly positive probability of default. Furthermore, in order to avoid the default costs of seizing the collateral, the equilibrium loans will be longer term, as in the mortgage market, where we see defaults and long-maturity loans.

2.2 The Crisis Stage

The crisis stage of the leverage cycle always seems to unfold in the same way. First there is bad news. That news causes asset prices to fall based on worse fundamentals. Those price declines create losses for the most optimistic buyers, precisely because they are typically the most leveraged. They are forced to sell off assets to meet their margin restrictions, even when the margins stay the same. Those forced sales cause asset prices to fall further, which makes leveraged buyers lose more. Some of them go bankrupt. And then typically things shift: the loss spiral seems to stabilize—a moment of calm in the hurricane's eye. But that calm typically gives way when the bad news is the scary kind that does not clarify but obscures the situation and produces widespread uncertainty and disagreement about what will happen next. Suddenly, lenders increase the margins and thus deliver the fatal blow. At that point, even modestly leveraged buyers are forced to sell. Prices plummet. The assets eventually make their way into hands that will take them only at rock-bottom prices.

During a crisis, margins can increase 50 percent overnight, and 100 percent or more over a few days or months. New homeowners might be unable to buy, and old homeowners might similarly be unable to refinance even if the interest rates are lowered. But, holding long-term mortgages, at least they do not have to put up more cash. For Wall Street firms, the situation is more dire. They often borrow for one day at a time in the repo market. If the margins double the next day, then they immediately have to double the amount of cash they hold for the same assets. If they do not have all that cash on hand, they will have to sell the assets. This is called deleveraging.

All this would happen even if traders were completely rational, processing information dispassionately. When we add the possibility of panic and the turmoil created by more and more bankruptcies, it is not surprising to see lending completely dry up.

2.3 The Aftermath of the Crisis

After the crisis ends, many businesses and individuals will be broke and unemployed. Parts of the economy will be disrupted, and some markets may be on the verge of shutting down. The government will then face the choice of who to assist, and at what cost. This assistance will typically be very inefficient, causing further losses to economic productivity. Doubts about which firms will survive will create more uncertainty, contributing to a difficult lending environment.

2.4 What Is So Bad about the Leverage Cycle?

The crisis stage is obviously bad for the economy. But the leverage that brings it on stimulates the economy in good times. Why should we think the bad outweighs the good? After all, we are taught in conventional complete-markets economics that the market decides best on these types of trade-offs. In Geanakoplos (2010), I discuss eight reasons why the leverage cycle may nevertheless be bad for the economy. The first three are caused by the large debts and numerous bankruptcies that occur in big leverage cycles.

First, optimistic investors can impose an externality on the economy if they internalize only their private loss from a bankruptcy in calculating how much leverage to take on. For example, managers of a firm calculate their own loss in profits in the down states, but sometimes neglect to take into their calculations the disruption to the lives of their workers when they are laid off in bankruptcy. If, in addition, the bankruptcy of one optimist makes it more likely in the short run that other optimists (who are also ignoring externalities) will go bankrupt, perhaps starting a chain of defaults, then the externality can become so big that simply curtailing leverage can make everybody better off.

Second, debt overhang destroys productivity, even before bankruptcy, and even in cases when bankruptcy is ultimately avoided. Banks and homeowners and others who are underwater often forgo socially efficient and profitable activities. A homeowner who is underwater loses much of the incentive to repair a house, even if the cost of the repairs is less than the gain in value to the house, since increases in the value of the house will not help him if he thinks he will likely be foreclosed eventually anyway.[10]

Third, seizing collateral often destroys a significant part of its value in the process. The average foreclosure of a subprime loan leads to recovery of only 25 percent of the loan, after all expenses and the destruction of the house are taken into account, as I discuss later. Auction sales of foreclosed houses usually bring 30 percent less than comparable houses sold by their owners.

The next four reasons stem from the swings in asset prices that characterize leverage cycles. A key externality that borrowers and lenders in both the mortgage and repo markets do not recognize is that if leverage were curtailed at the high end of the leverage cycle, prices would fall much less in the crisis. Foreclosure losses would then be less, as would inefficiencies caused by agents being so far underwater. One might argue that foreclosure losses and underwater inefficiencies should be taken into account by a rational borrower and lender and be internalized: it may be so important to get the borrower the money, and the crisis might ex ante be so unlikely, that it is "second best" to go ahead with the big leverage and bear the cost of the unlikely foreclosure. But that overlooks the pecuniary externality: by going into foreclosure, a borrower lowers housing prices and makes it more likely that his neighbor will do the same.

Fifth, asset prices can have a profound effect on economic activity. As James Tobin argues with his concept of Q, when the prices of old assets are high, new productive activity, which often involves issuing financial assets that are close substitutes for the old assets, is stimulated. When asset prices are low, new activity might grind to a halt.[11] When asset prices are well above the complete-markets price, because of the expectation by the leveraged few that good times are coming, a huge wave of overbuilding usually results. In the bad state, this overbuilding needs to be dismantled at great cost and, more importantly, new building nearly stops. To make the point a bit more dramatically, very high leverage means that the asset prices are set by a small group of investors. If agent beliefs are heterogeneous, why should the prices be determined entirely by the highest outliers? In the current crisis, as I observed earlier, the $2.5 trillion of toxic mortgage securities were purchased with about $150 billion in cash and $2.35 trillion in loans. As of 2006, just two men, Warren Buffet and Bill Gates, between them had almost enough money to purchase every single toxic mortgage security in the whole country. Leverage allows the few to wield great influence on prices and therefore on what is produced.[12]

Sixth, a large group of small businesspeople who cannot buy insurance against downturns in the leverage cycle can easily sell loans to run their businesses or pay for their consumption in good times at the height of the leverage cycle, but have a hard time at the bottom. Government policy may well have the goal of protecting these people by smoothing out the leverage cycle.[13]

Seventh, the large fluctuations in asset prices over the leverage cycle lead to massive redistributions of wealth and changes in inequality. When leverage $\lambda = 30$, there can be wild swings in returns and losses. In the ebullient stage, the optimists become rich as their bets pay off, while in the down states, they might go broke. Inequality becomes extreme in both kinds of states.[14]

The eighth problem with the leverage cycle is caused by the inevitable government responses to the crisis stage. In an effort to mitigate the crisis, the government often intervenes in inefficient ways. In the current crisis, the government is supporting the financial sector by holding the federal funds rate near zero. The government's foreclosure prevention efforts have created financial subsidies for households that opt not to move, which can create inefficiencies in labor market adjustment.[15] Government bailouts, even if they were all for the public good, cause resentment from those who are not bailed out. The agents in the economy do not take into account that by leveraging more and putting the economy at greater

[10] See Myers (1977) and Gyourko and Saiz (2004).

[11] See Tobin and Golub (1998).

[12] Standard economics does not really pay any attention to the case where agents have different beliefs, and median beliefs are closer to the truth than extreme outliers.

[13] Here I rely on Tobin's Q and the absence of insurance markets. The small businessmen cannot insure themselves against the crisis stage of the leverage cycle. In conventional complete-markets economics, they would be able to buy insurance for any such event. Geanakoplos and Polemarchakis (1986) offer a proof that when insurance markets are missing, there is almost always a government intervention in the existing markets that will make everyone better off.

[14] This is a purely paternalistic reason for curtailing leverage.

[15] See Ferreira et al. (forthcoming).

risk, they create more inefficient government interventions. And of course, the expectation of being assisted by the government, should things go wrong, causes many agents to be more reckless in the first place.[16]

3. The Leverage Cycle of 2000-09 Fits the Pattern

3.1 Leverage and Prices

By now, it is obvious to everybody that asset prices soared from 1999 (or at least after the disaster period that began September 11, 2001) to 2006, and then collapsed from 2007 to 2009. My thesis is that this rise in prices was accompanied by drastic changes in leverage, and was therefore just part of the 1999-2006 upswing in the leverage cycle after the crisis stage in 1997-98 at the end of the last leverage cycle. I do not dispute that irrational exuberance and then panic played a role in the evolution of prices over this period, but I suggest that they may not be as important as leverage; certainly, it is harder to regulate animal spirits than it is leverage.

Let us begin with the housing bubble, famously documented by Robert Shiller. In Chart 1, I display the Case-Shiller national housing index for 2000-09. It begins at 100 in 2000:1, reaches 190 in 2006:2, and falls to 130 by 2009:1, as measured on the right vertical axis. But I superimpose on that graph a graph of leverage available to homeowners each month. This is measured on the left vertical axis and labeled "Down payment for mortgage," which is 100 percent minus the loan-to-value (LTV) ratio. To compute this, I begin by looking house by house each month from 2000-09 at the ratio of all the outstanding mortgage loans (usually a first and sometimes a second lien) to the appraised value of the house at the moment a first mortgage was issued for every subprime and alt-A house available in the First American CoreLogic LoanPerformance Data Base. I then average over the 50 percent houses with the highest LTV levels.[17] In this way, I obtain a robust estimate of leverage offered to homeowners. By leaving out the bottom 50 percent, I ignore homeowners who clearly chose to leverage less than they could have, and by including all homes in the top 50 percent, I ensure that the leverage measure was really available and not just a special deal for a few outliers. If anything, my numbers underestimate the offered leverage.[18]

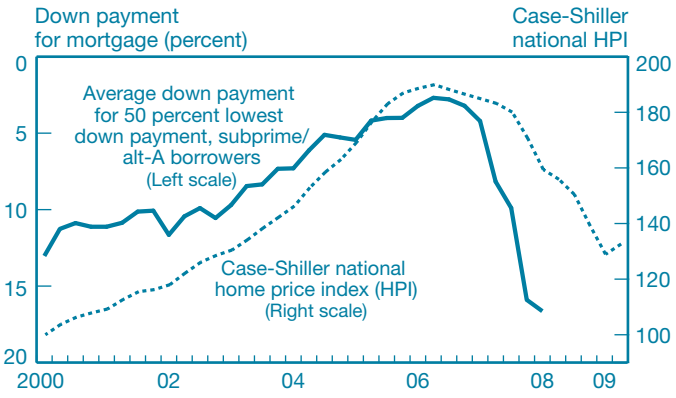
[16] This mechanism has been formalized in Farhi and Tirole (2009).

[17] These data were compiled and analyzed by the research team at the hedge fund Ellington Capital Management.

Chart 1

Housing Leverage Cycle

Margins Offered (Down Payments Required) and Home Prices



Sources: First American CoreLogic LoanPerformance Data Base; Ellington Capital Management.

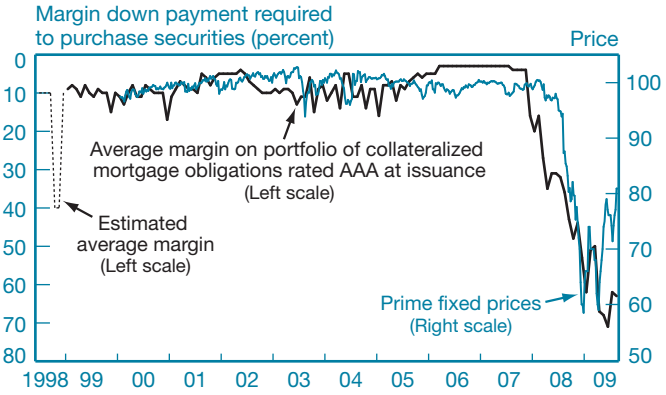
Notes: The down payment axis has been reversed, because lower down payment requirements are correlated with higher home prices. For every alt-A or subprime first-lien loan origination from 2000:1 to 2008:1, the down payment percentage was calculated as appraised value (or sale price, if available) minus total mortgage debt, divided by appraised value. For each quarter, the down payment percentages were ranked from highest to lowest, and the average of the bottom half is shown. This number is an indicator of the down payment required; clearly, many homeowners put down more than they had to, which is why the top half is dropped from the average. A 13 percent down payment in 2000:1 corresponds to leverage of about 7.7, and a 2.7 percent down payment in 2006:2 corresponds to leverage of about 37. Subprime/alt-A issuance ended in 2008:1.

It is striking how correlated prices and leverage are, rising and then falling together. Especially noteworthy is that leverage peaks in 2006:2, with 2.7 percent down, exactly when housing prices peak, and heads down much faster than housing prices.

In Chart 2, I present the history of the J.P. Morgan AAA prime floater mortgage index from about 2000 to 2009. The index is measured on the right vertical axis. The prime mortgages underlying the bonds in the index were taken out by investors with pristine credit ratings, and the bonds are also protected by some equity in their deals. For most of its history, this index stays near 100, but starting in early 2008, it falls rapidly, plummeting to 60 in early 2009. The cumulative losses on these prime loans even today are still in the single digits; it is hard to imagine them ever reaching 40 percent (which would mean something like 80 percent foreclosures with only 50 percent recoveries). It is of course impossible to know what people were thinking about potential future losses when the index fell to 60 in late 2008 and early 2009. My hypothesis is that leverage played a big role in the price collapse.

[18] At the peak of nonprime lending in mid-2005, these loans represented 45 percent of the flow of new mortgage borrowing (correspondence with editors).

Chart 2
Securities Leverage Cycle
Margins Offered and AAA-Rated Securities Prices



Sources: Ellington Capital Management; J.P. Morgan.

Notes: The chart represents the average margin required by dealers on a hypothetical portfolio of bonds subject to certain adjustments described below. The margin axis has been reversed, because lower margins are correlated with higher prices. The portfolio evolved over time, and changes in average margin reflect changes in composition as well as changes in margins of particular securities. In the period following August 2008, a substantial part of the increase in margins is attributable to bonds that could no longer be used as collateral after being downgraded, or for other reasons, and hence count as 100 percent margin.

On the left vertical axis, I give the loan-to-value, or, equivalently, the down payment or margin, *offered* by Wall Street banks to the hedge fund Ellington Capital Management on a changing portfolio of AAA mortgage bonds.[19] As I noted earlier, it is astonishing that the Fed itself does not have such historical data. Fortunately, the hedge fund Ellington, which I have worked with for the past fifteen years, does keep its own data. The data set is partly limited in value by the fact that the data were only kept for bonds Ellington actually followed, and these changed over time. Some of the variation in average margin is due to the changing portfolio of bonds, and not to changes in leverage. But the numbers, while not perfect, provide substantial evidence for my hypothesis and tell a fascinating story. In the 1997-98 emerging markets/mortgage crisis, margins shot up, but quickly returned to their previous levels. Just as housing leverage picked up over the period after 1999, so did security level leverage. Then in 2007, leverage dramatically fell, falling further in 2008, and leading the drop in security prices. Very recently, leverage has started to increase again, and so have prices.

[19] These are the offered margins and do not reflect the leverage chosen by Ellington, which since 1998 has been drastically smaller than what was offered.

Chart 3
VIX Index

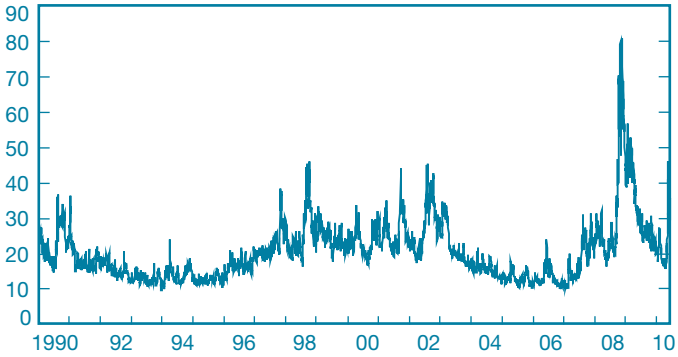


Chart 3 displays the history of implied volatility for the S&P 500, called the VIX index. Volatility in equities is by no means a perfect proxy for volatility in the mortgage market, but it is striking that the VIX reached its peak in 2008 at the crisis stage of the current leverage cycle, and reached a local peak in 1998 at the bottom of the last leverage cycle in fixed-income securities. The VIX also shot up in 2002, but there is no indication of a corresponding drop in leverage in the Ellington mortgage data.

3.2 What Triggered the Crisis?

The subprime mortgage security price index collapsed in January 2007. The stock market kept rising until October 2007, when it too started to fall, losing eventually around 57 percent of its value by March 2009 before rebounding to within 27 percent or so of its October peak in January 2010. What, you might wonder, was the cataclysmic event that set prices and leverage on their downward spiral?

The point of my theory is that the fall in prices from scary bad news is naturally going to be out of proportion to the significance of the news, because the scary bad news precipitates and feeds a plunge in leverage. A change in volatility, or even in the volatility of volatility, is enough to prompt lenders to raise their margin requirements. The data show that that is precisely what happened: margins were raised. But that still begs the question, what was the news that indicated volatility was on the way up?

One obvious answer is that housing prices peaked in mid-2006, and their decline was showing signs of accelerating in the beginning of 2007. But I do not wish to leave the story there. Housing prices are not exogenous; they are central to the leverage cycle. So why did they turn in 2006?

3.3 Why Did Housing Prices Start to Fall?

Many commentators have traced the beginning of the subprime mortgage crisis to falling housing prices. But they have not asked why housing prices started to fall. Instead, they have assumed that housing prices themselves, fueled on the way up by irrational exuberance and on the way down by a belated recognition of reality, were the driving force behind the economic collapse.

I see the causality going in the other direction, starting with the turnaround in the leverage cycle. The leverage cycle was of course greatly exacerbated by the terrible consequences of falling housing prices, which then fed back to cause further housing declines.

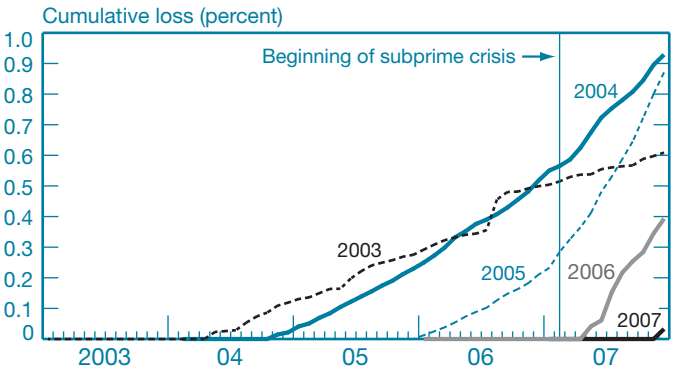
As I hope I have made clear, in my view housing prices soared because of the expansion of leverage. Greater leverage enabled traditional buyers to put less money down on a bigger house, and therefore pushed up housing prices. It also enabled people to buy houses who previously did not have enough cash to enter the market, pushing housing prices up even further.

There is, however, a limit on how much leverage can increase, and on how many new people can enter the market. Though negative amortizing loans pushed the envelope, no money down is a natural threshold beyond which it is hard to move. And as more and more households entered the market with less and less money down, lenders began to become apprehensive that these people were less reliable and more inclined to exercise their put option to walk away from the house if housing prices fell. The rapidly expanding supply of new housing demand, fueled by access to easy mortgages, began to slow for completely rational reasons, not because of a sudden pricking of irrational exuberance. This naturally led to a peak in housing prices by 2006:2. But this does not explain why housing prices should steeply decline. Indeed, over the next two quarters, prices and leverage waffled, both moving slightly in a negative direction: During the last half of 2006, housing down payment requirements rose slightly, from 2.7 percent to 3.2 percent, and prices fell slightly, by 1.8 percent.

At that point, bad news appeared in the securities market in the form of rising delinquencies. Charts 4 and 5 show losses and delinquencies of Countrywide deals by vintage.[20] (These deals are fairly representative of the whole subprime market.)

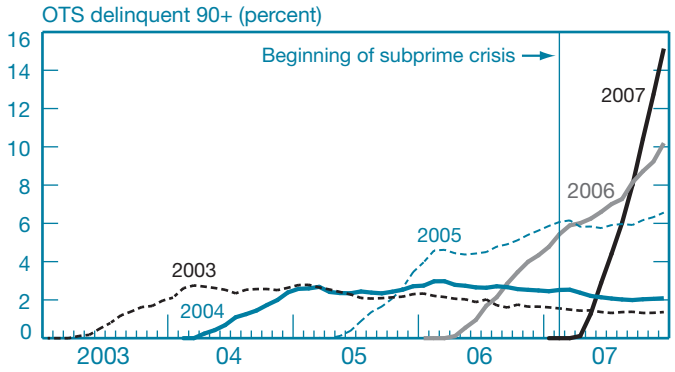
One can see in Chart 4 that by January 2007, losses for the 2005 vintage were just 0.2 percent and losses for the 2006 vintage were nonexistent. But the 2005 and 2006 delinquencies displayed in Chart 5 were already approaching 5 percent, more than double those of previous vintages. More disturbing, they showed no signs of leveling off. This is precisely the kind of scary news that creates wide uncertainty about what might happen next. With that new information, how much extrapolation should a buyer from 2006 have made in his expectations of losses and delinquencies going forward?

Chart 4
Cumulative Loss of Original Balance



Source: Ellington Capital Management.

Chart 5
Delinquencies on Original Balance

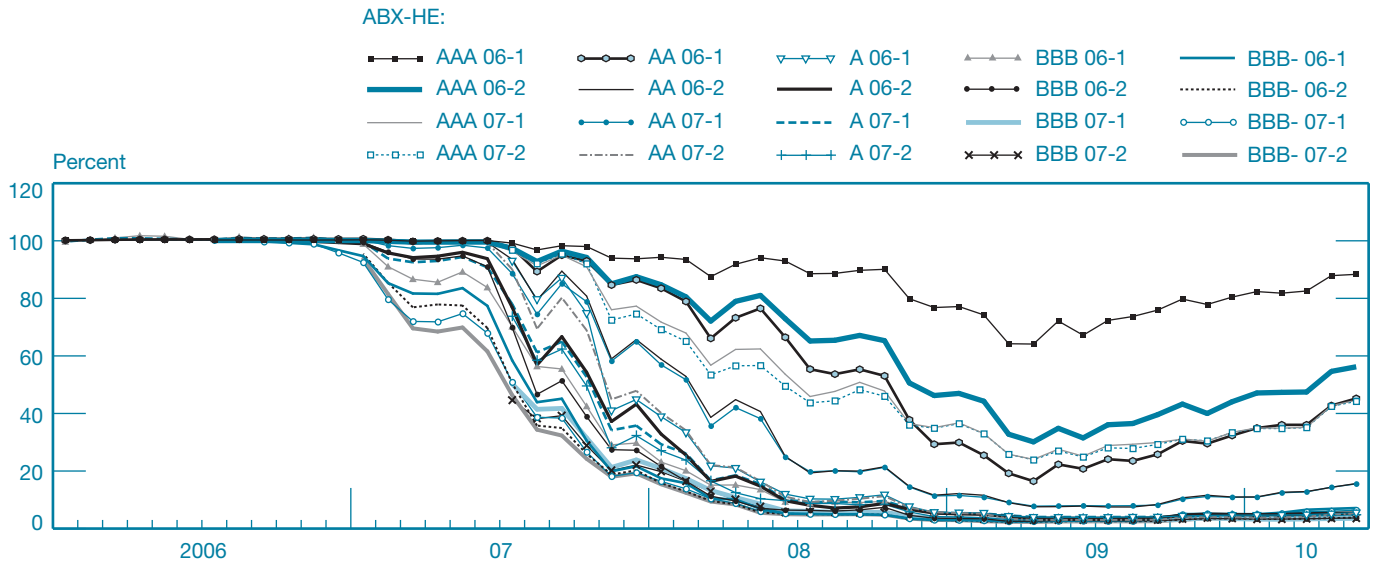


Source: Ellington Capital Management.

The ABX index for 2006 vintage subprime bonds began to fall in November 2006 with the smallest trickle of bad news about homeowner delinquencies, then spiked downward in January 2007 after the year-end delinquency report (Chart 6). This price drop of 2006 BBB bonds to below 80 implied that the market was suddenly anticipating huge losses on subprime deals on the order of 10 percent. Recall that for a pool of mortgages to lose 9 percent or 10 percent of its value, the market must anticipate that something like 30 percent of the homeowners will be thrown out of their houses, with 30 percent losses on the mortgage on each home sold (30 percent x 30 percent = 10 percent). This expectation turned out to be not pessimistic enough, but at that time it was a heroic extrapolation from the observed delinquencies of less than 5 percent.[21]

[20] Data were provided by Ellington Capital Management.

Chart 6
ABX Index

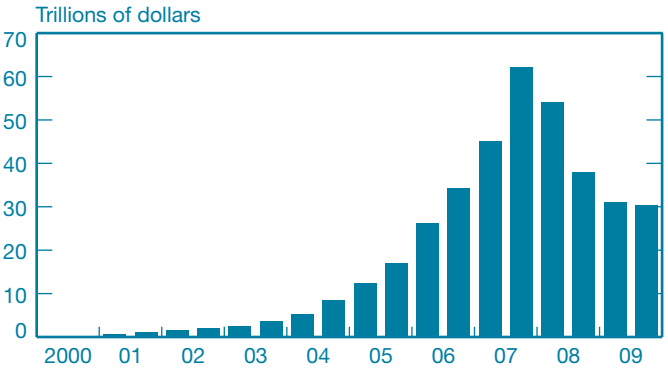


My contention is that this sudden drop in prices, and the further price declines later, were not simply the result of a drop in expected payoffs (that is, in fundamentals) by the same old buyers, but also the result of a change in the marginal buyer. A critical new downward force entered the market for mortgage securities. Standardized credit default swaps (CDS) on mortgage bonds were created for the first time in late 2005, at the very height of the market. The volume of CDS expanded rapidly throughout 2006 and especially in 2007 (Chart 7).[22] A CDS is an insurance contract for a bond. By buying the insurance, the pessimists for the first time could leverage their negative views about bond prices and the houses that backed them. Instead of sitting out of the subprime securities market, pessimists could actively push bond prices down. Their purchase of insurance is tantamount to the creation of more ("synthetic") bonds; naturally, the increase in supply pushed the marginal buyer down and thus the price down.

In January 2007, after the dramatic fall in BBB subprime mortgage prices, housing prices were still only 1.8 percent off their peak. Though the peak of the housing market preceded the peak of the securities market, the collapse in securities prices preceded the significant fall in housing prices. Thus, in my view the trigger for the downturn in bonds was the bad news about delinquencies and the concurrent creation of the standardized CDS market in subprime mortgage indexes, which then spilled over into the housing market.

The downward pressure on bond prices from credit default swaps and worrisome delinquency numbers meant that new securitizations became more difficult to underwrite. Securitizers of new loans looked for better loans to package in order to continue to back bonds worth more than the loan amounts they had to give homeowners. They asked for loans with more collateral. As Chart 7 shows, from 2006:4 to 2007:4,

Chart 7
Volume of Credit Default Swaps



Source: "ISDA Market Survey: Historical Data."

[21] The collapse of the ABX index in January 2007 is a powerful illustration of the potency of market prices to convey information. This first market crash should have been enough to alert our government to the looming foreclosure disaster, but three years later we still have not taken decisive action to mitigate foreclosures.

[22] Chart 7 is derived from data provided in "ISDA Market Survey: Historical Data," available at www.isda.org/statistics/historical/html. Unfortunately, it includes all CDS, not just CDS on mortgages. The data on mortgage CDS seem difficult to find, since these CDS were traded bilaterally and not on an exchange. It seems very likely to me that the mortgage CDS increased even more dramatically from 2004-05 to 2006-07.

the required down payment on houses rose dramatically from 3.2 percent to 15.9 percent (equivalently, LTV fell from 96.8 percent to 84.1 percent). This meant that potential new homeowners began to be closed out of the market, which of course reduced home prices. In that same period, housing prices began to fall rapidly, declining by 8.5 percent.

But more insidiously, the desire by lenders to have more collateral for each dollar loaned kept homeowners from refinancing because they simply did not have the cash: given the drop in the permissible LTV ratio, and the fall in housing prices, they suddenly needed to put down 25 percent of their original loan in cash to refinance. Refinancing virtually stopped overnight. Until 2007, subprime bondholders could count on 70 percent or so of subprime borrowers refinancing by the end of their third year.[23] These homeowners began in pools that paid a very high rate of interest because of their low credit rating. But after two years of reliable mortgage payments, they would become eligible for new loans at better rates, which they traditionally took in vast numbers. Of course, a prepayment means a full payment to the bondholder. Once refinancing plummeted and this sure source of cash disappeared, the bonds became much more at risk and their prices fell more. Margins on bonds began to tighten.

Mortgagees who had anticipated being able to refinance were trapped in their original loans at high rates; many subsequently became delinquent and entered foreclosure. Foreclosures obviously lead to forced sales and downward pressure on housing prices. And falling home prices are a powerful force for further price reductions, because when house values fall below the loan amount, homeowners lose the incentive to repay their loans, leading to more defaults, foreclosures, and forced selling. All this leads back to falling security prices and tighter margins on securities.

The feedback from falling security prices to higher margins on housing loans to lower house prices and then back to tougher margins on securities and to lower security prices and then back again to housing is what I call "the double leverage cycle."

4. Why this Leverage Cycle Is the Worst since the Great Depression

Every leverage cycle has the same broad features. The crisis stage of every leverage cycle is bad. But the current crisis is far worse than the crises we saw in the two previous leverage cycles. There are a number of reasons why this cycle is worse than all previous cycles since the Depression, but the unifying theme behind all of them is a failure to put up enough collateral to back promises.

4.1 Securities Leverage Got Higher then Fell Farther than Ever Before

In this cycle, leverage on traditional collateralizable assets increased to more than the highs from the previous cycle. That can be seen in the history of one mortgage hedge fund's margins (haircuts) over the last eleven years (Chart 2). Note in the chart that before the crisis of 1997-98 that ended the last leverage cycle, leverage was about 10 to 1 (margins were about 10 percent). During the 1998 crisis, margins jumped to 40 percent, staying there about two months, before returning to their previous levels of 10 percent. In the "great moderation" in the nine years afterward, when volatility got very low, leverage increased from about 10 to 1 to about 20 to 1 (the margins fell from 10 percent to 5 percent).

Beginning in 2007 (after reaching its peak in 2006), leverage collapsed, with margins going from 5 percent to 70 percent on average. Two years after the collapse, leverage was still low, whereas in 1998 the crisis was all over in two months.

The most dramatic change in margins has come from assets that were rated AAA, and that have been, or are about to be, downgraded. Previously, one could borrow 90 or even 98.4 cents on a dollar's worth of AAA assets, and now one cannot borrow anything at all with these assets as collateral. According to Moody's, AAAs are supposed to have a 1 in 100 risk of default over a ten-year period.[24] We are now seeing over 50 percent of all alt-A and subprime AAA bonds partially defaulting, and we will see virtually 100 percent of all AAA collateralized debt obligations (CDOs) partially default. Even when some assets have little or no chance of losing more than a few percent of their value, the market no longer trusts the AAA rating, and lenders will not lend anything on them.

In the run-up to the present crisis, financial innovation enabled many new kinds of assets to become usable as collateral. Thus, even if margins had not declined on old collateral, the leverage of the economy as a whole would have increased because there was new borrowing backed by previously unusable collateral, which brings us to pooling and securitization.

The process of pooling and securitization has been a crucial source of new collateral and increased leverage. Imagine a single subprime mortgage loan. Even in the days when it was believed that the expected loss from such a mortgage was between 1 percent and 4 percent, people still recognized that

[23] Seventy-four percent of all subprime loans issued in or before 2004 had refinanced by the end of their third year, according to the First American CoreLogic LoanPerformance Data Base.

[24] See Backman and O'Connor (1995).

there was a nontrivial chance of a much bigger loss on a single loan. Lenders, inherent pessimists, would not have considered lending using a single subprime mortgage as collateral. But now consider a pool of subprime mortgages from around the country. If one believed that the loans were independent, so that a housing price decline in Detroit did not imply a housing price decline in California, then on a big enough pool of loans, the chance for more than 30 percent default might be considered less than 1 in 10,000. Even a very pessimistic lender who believed in a 4 percent expected loss per loan would be willing to lend 70 percent of the value of the entire pool, provided that he got paid before anyone else. Thus, a buyer of the pool of mortgages could imagine borrowing 70 percent of their collective value, when it would have been impossible to borrow anything on the individual loans.

Securitization took this borrowing on pools one step further by converting the loans into long-term loans. The underwriter of the pool typically issued different bonds, whose payments depended on the homeowners' payments on their loans. Consider, for example, a bond structure with just two "tranches" of bonds. The senior tranche might pay interest slightly above the riskless government rate on the best 70 percent of the loans. As long as losses on the pool are below 30 percent, the senior tranche holder continues to get paid his interest and eventually his principal. The junior bondholder receives what is left from the pool after the senior bondholder is paid. The whole securitized structure can be interpreted as if the buyer of the junior piece actually bought the whole pool, using a long-term loan from the buyer of the senior piece, collateralized by the whole pool. Once one understands the juniors as effectively borrowing from the seniors, it becomes clear how the rapid spread of securitization over the last thirty years, but especially over the last ten years, dramatically increased the leverage in the system.

Another factor that dramatically increased overall leverage in the system is the credit default swap, which I discuss shortly.

4.2 Housing and the Double Leverage Cycle

Leverage on houses got to be much higher in this leverage cycle. In the recent leverage cycles, ending in 1994 and 1998, homeowner leverage did not get remotely as high as it did in the recent cycle. In 2006, many homeowners were borrowing with basically no money down, or as little as 3 percent, as we saw in Chart 1.[25] New mortgages like option arms were invented, which abetted this mad rush to loan homeowners all or nearly all of the purchase price. Whereas previous cycles' leverage involved many financial institutions, it never involved such a large fraction of the general population. When housing prices and securities prices fell, millions of homeowners as well as many of the most venerable financial institutions in America found themselves underwater, owing more money than the value of their assets.

Thus, the current cycle is really a double leverage cycle: not only are the mortgage securities subject to the leverage cycle, but their "fundamental" cash flows (namely, homeowner mortgage payments) are also subject to the leverage cycle. These two cycles feed off each other. When margins are raised on homeowners, it becomes more difficult to get a new mortgage and home prices fall, jeopardizing mortgage securities backed by houses. But more importantly, it becomes more difficult for homeowners to refinance their old loans, putting these loans and the securities they back in much more jeopardy of defaulting. Similarly, when margins on securities are raised and their prices fall, then in order to sell the securities for higher prices, underwriters demand better underlying mortgages, that is, more money down from home buyers.

4.3 Credit Default Swaps

The current cycle has been more violent because of the standardization/creation of the derivative credit default swap market for mortgages in 2005, just at the top of the leverage cycle. One reason for the abruptness of the fall is that CDS allowed pessimists to leverage at just the worst time. Once CDS emerged, they were bound to put downward pressure on prices, because they allowed pessimists to express their views for the first time and indeed leverage those views. Had the CDS market for mortgages been around from the beginning, asset prices might never have gotten so high. But their appearance at the very top of the cycle guaranteed that there would be a fall.

Not only did CDS allow pessimists to leverage for the first time, it also allowed them to leverage more than optimists. When a bond trades near 100, but there is a perceptible chance of a big drop in price, then in a rational world the writer of insurance is almost always going to be asked to put up much more collateral than the buyer of insurance, because his potential liability is so high. A small group of pessimists can therefore have an outsized negative impact on prices by leveraging their CDS positions, since traders on the other side will need far more capital to offset those positions.

A second reason why CDS made the fall much worse is that in practice they allowed optimists to leverage even more than they had before. To the extent that CDS did not lower prices before any bad news, it was because leveraged optimists increased their leverage by taking the other side of the CDS, on

[25] See Haughwout, Peach, and Tracy (2008) for details on leverage used for nonprime borrowers from 2001 to 2007.

top of their leveraged purchases of the underlying assets. But this made the crash much bigger once the bad news hit. CDS is a kind of insurance market for bond defaults, but instead of cushioning losses, it made them much worse because often the buyers of the bonds did not buy the insurance, they sold it.[26]

One might mistakenly think that CDS should just wash out. In other words, for every dollar lost on the insurance, there should be a dollar gained by the recipient. But the optimistic writers of insurance are very different from the pessimistic buyers of insurance. When the bad news hits, the former lose and must reduce their purchases of assets; the latter gain, but still will not buy the assets. Writers of CDS insurance expose the economy to the same problems of excessive leverage I described earlier.

This brings us to the question of just how much leverage one could actually obtain via the CDS market. Imagine a bond with $100 face value that is trading for $98, and imagine a CDS insurance contract promising $1 for every $1 the bond defaults. The $98 price suggests expected losses to the insurance writer of $2. If the bond rises to $99, the seller of insurance effectively makes a dollar and if the bond price falls to $97, the insurance writer effectively loses $1. Thus, writing insurance is tantamount to owning the bond. One can therefore compare the collateral a writer of CDS insurance had to put up with the down payment a buyer of the bond would have had to make to see where leverage was higher. It now appears that leverage was higher with CDS. Many firms, like AIG, were allowed to write CDS insurance with little or no initial margin. If enough collateral had been put up by AIG, there would have been no reason to bail it (or more to the point, all its counterparties) out.

The failure of some buyers of CDS insurance to insist on proper collateral from the writers of the insurance was made far worse because the gains and losses from CDS are not netted. A Firm B that was neutral, betting one way against Firm A on tranche BBB, and betting the opposite way on the same tranche against Firm C, could come out a loser anyway. If Firm A defaults on its insurance payment, then B will be unpaid by A but still on the hook for paying C. So instead of just one Firm A going bankrupt and another Firm C going unpaid in the absence of collateral, as would happen with netting, another Firm B might also go bankrupt, closing shop, firing workers, and creating other social costs.

Losses by leveraged buyers of assets can cause a chain reaction when a margin call forces a leveraged buyer to sell, which might lower the price and force another leveraged buyer to sell and so on. But with uncollateralized CDS, the chain reaction is more direct: Firm B loses the money irrespective of market prices. The implication I draw later is that there are benefits from CDS being traded on an exchange instead of in bilateral contracts, both to ensure that collateral is always posted by the writer of the insurance and to make sure losses are netted.

Another benefit of putting CDS on an exchange would be the ease with which size and leverage could be monitored by regulators. In traditional insurance law, as I understand it, there is a prohibition against overinsuring by taking out insurance for more than the underlying asset, precisely because of the moral hazard such practices entail. Similar prohibitions could be adopted for CDS.[27]

4.4 Counterparty Risk

In bilateral CDS contracts, it was often the case that the insurer did not post enough initial margin collateral to guarantee payment after a big move in default probabilities. This CDS problem illustrates a more general flaw in the whole system of contracting on Wall Street. These contracts to a great degree were written in such a way that only one side of every transaction was presumed liable to default, so that only the other side needed protecting. For example, in the repo market, a hedge fund borrower gets a loan from an investment bank, and puts up collateral at the bank worth more than the loan. The investment bank is protected against the potential default of the hedge fund, because in that event the collateral can be sold to recover the loan amount. But the contract does not contemplate the bankruptcy of the investment bank. What recourse does the hedge fund have if the investment bank goes out of business, shutting its doors and swallowing the collateral security? Following the Lehman bankruptcy, traders who never before had to give a second thought to these counterparty risk questions suddenly had to reevaluate all their contracts, with disastrous effects on liquidity and price discovery.

Now, this unplanned-for counterparty risk has become the primary rationale for the government's seemingly unending commitment to inject capital into "too-big-to-fail" institutions. "We can't afford another Lehman," is the common refrain; we had to intervene with AIG not because it was so vital, but because if it defaulted a chain reaction might ensue.

The prospective solution to the counterparty risk problem is to ensure that both sides put up enough collateral. Of course, people are now more alert to their counterparty vulnerability than they were before, and thus pressure will grow, for example, on repo lenders to warehouse the

[26] Of course, there were undoubtedly some hedge funds that bought bonds they thought were undervalued, and bought insurance on similar bonds in order to hedge their position against the risk of a market downturn. These are the leveraged buyers that survived the crisis without a bailout. AIG is a classic example of a writer of CDS insurance on mortgages that also held mortgage securities (see Congressional Oversight Panel Report, June 10, 2010).

[27] See "A Daring Trade Has Wall Street Seething," *Wall Street Journal*, June 12, 2009, about a writer of CDS insurance who found a way to make the bond pay off to avoid paying the overinsurance.

collateral at a third site that would not be compromised by the bankruptcy of the lender. This raises questions about whether there is enough collateral in the economy to back all the promises people want to make, which I discuss at length in Geanakoplos (1997) and Geanakoplos and Zame (2009). But I believe there could be a government initiative to move as many bilateral contracts onto exchanges as possible; agents trading with the exchange will be required to put up collateral, and the netting through the exchange will economize on the collateral. As for any finance-related bilateral contracting so particular that it could not be moved to an exchange, the parties could either accept strict disclosure requirements and limits on how much of this contracting they could engage in or accept doing without the instruments altogether.

4.5 Government Laxity, Deregulation, and Implicit Guarantees Increased Leverage

The mildness and shortness of the crisis stage of the last two leverage cycles, in 1994 and 1998, may have led many people, perhaps including the regulators, to ignore leverage altogether. The abrupt tightening of margins in 1998 was explained by the supposed irrationality of lenders, who it was said reacted by raising margins after the fact, that is, after the fall in prices had already occurred. It appears that virtually no lenders lost money on loans against mortgage securities in that crisis. The run-up in asset prices and home prices during the current cycle was attributed mostly to irrational exuberance, instead of being understood, first and foremost, as an inevitable consequence of the increase in leverage. Partly as a result of this faulty narrative, government authorities did nothing to curtail the dramatic growth in homeowner leverage, or consumer leverage more generally, or corporate leverage, or securities leverage. Banks were allowed to move assets off their balance sheets and thus avoid capital requirements, further increasing their leverage.

Not only did the Fed (and everyone else) react passively to the rising leverage pervading the system, it encouraged the deregulation that unleashed the leverage inherent in outsized credit default swaps. As I mentioned earlier, outsized CDS contracts seem on their face to be either gambling or writing insurance in excess of the value of the property being insured. Under either interpretation, they would have run afoul of state laws prohibiting gambling or overinsurance. Thus, it took a positive act of Congress to pass legislation in the Commodity Futures Modernization Act of 2000 exempting CDS from those limitations.

Perhaps the most important and unwitting government stimulus to the increased leverage was the implicit government guarantees for entities that were considered too-big-to-fail. Fannie Mae and Freddie Mac grew bigger and bigger. The presumed government guarantee on their promises enabled them to leverage their assets to 30 or more, and still issue debt just above Treasury rates. Without this implicit government backing, they would never have been able to borrow so much with such little capital.

Many investment banks were allowed to write CDS without collateralizing their implicit promises, as I observed before. It seems virtually inexplicable that Wall Street overlooked this counterparty risk; more likely, many counterparties assumed that these firms were implicitly backstopped by the Fed or the Treasury. And indeed, despite some doubts when Lehman collapsed, that expectation proved correct.[28]

4.6 The Rating Agencies Effectively Increased Leverage

The expansion of the mortgage market into less creditworthy households made it more likely that a shock would someday be "big and bad and scary," creating more uncertainty and more disagreement. The anticipation of that, however remote the possibility seemed, should have made lenders nervous and caused them to put a brake on leverage. This rational concern was dramatically reduced by a faith many investors had in the rating agencies and their default models, which were widely relied upon by market participants (and the rating agencies themselves), but which failed to account adequately for the probability that defaults in certain circumstances would be highly correlated. Some investors forgot the incentives of the rating agencies and the incentives of many market actors to downplay seriously the probability of highly correlated defaults. In the face of a long history of low defaults and with billions of dollars of deals waiting on the blessing of a small handful of rating agency actors, it would have been astonishing if ratings had been as tough as they should have been. The same lesson applies to the mortgage brokers who were able to collect fees for signing up borrowers without facing any losses themselves if the borrowers defaulted.

4.7 Global Imbalances Increased Leverage

Caballero, Farhi, and Gourinchas (2008), Caballero (2010), and others have suggested that the enormous savings glut

[28] Bear Stearns was sold to J.P. Morgan, which took on Bear's obligations, but only after the government guaranteed $29 billion of Bear's assets. Many other investment banks, like Goldman Sachs, were given emergency injections of $10 billion of Troubled Asset Relief Program (TARP) money.

coming from Asia increased the demand for safe assets. This presented a profit opportunity to American financiers, who were thus stimulated to engineer the securitizations that created apparently safe bonds out of risky assets. It is hard to assess how important this factor is, but surely a gigantic demand for safe bonds would indeed give a big incentive to create those bonds and thus inevitably to concentrate more risk in other bonds. However, that leaves unexplained why investors were willing to buy those other bonds, or why investors bought so much of the new, "safe" AAA-rated bonds even when their yields revealed that the market did not think they were perfectly safe. The Chinese, for example, did not buy these bonds and they did not lose money when they subsequently defaulted. The global-imbalances hypothesis relies on an additional mechanism for its power: global imbalances created lower, truly safe rates, which led American investors pursuing absolute yields to leverage more, for example, by buying the new, "safe" bonds with borrowed money to leverage their tiny excess spreads. Thus, we come back to leverage.

4.8 All Upside Down

The upshot of the huge credit boom and the plunging prices was that an extraordinary number of households, businesses, and banks ended up upside down or underwater, that is, with debt exceeding their assets. According to First American CoreLogic, about 13 million of the 55 million mortgage holders were underwater in early 2010. According to Lender Processing Services, about 2 million families have lost their homes since 2007, 2.5 million more are in foreclosure, and another 3 million are not currently paying their mortgages.

The government has assumed trillions of dollars of mortgage debt through its guarantee of Fannie Mae and Freddie Mac and through its Federal Housing Authority (FHA) loans, and has invested hundreds of billions of dollars supporting banks and firms like AIG; in addition, on account of the huge number of failing banks, the Federal Deposit Insurance Corporation is on the verge of borrowing from the Treasury. A problem of too much private debt has morphed into a problem of too much government debt.

4.9 Why Didn't Wall Street Risk Managers Anticipate the Collapse?

Having discussed many of the factors that exacerbated the crisis of 2007-09, I am now in a position to assess the widely held view that nobody saw it coming.

Nobody doubts that Wall Street understood that there was considerable risk in subprime mortgage pools. That is why they were tranched into different tiers, called AAA, AA, and down to BBB. And these bonds were all senior to residual pieces and overcollateralization, which together provided another 8 percent of protection. So, the question is really not whether Wall Street overlooked the risk, but rather how did it come to be that Wall Street so badly underestimated the size of the risk?

The answer, I believe, is that it was nearly impossible to foresee the devastating consequences of the multiple feedbacks between securities and houses embodied in the double leverage cycle. Complex adaptive systems are notoriously hard to predict. Contrary to the myth that nobody imagined that housing prices could go down as well as up, I suspect that virtually every large bank and hedge fund considered a scenario in which housing prices went down at least 10 percent. Recall that if 25 percent of the loans result in homeowners being thrown out of their houses, with 25 percent losses on each foreclosed home, that amounts to losses of just 6.25 percent = .25 x .25 for the pool as a whole, which would leave the rated bonds unscathed. Better still, if 70 percent of the homeowners refinanced according to historical patterns, then even with 50 percent defaults and 50 percent losses on the remaining 30 percent of the loans, losses would come only to 6.75 percent = 30 percent x .5 x .5. But how many anticipated that at the same time as housing prices went down mortgage down payments would rise to the point that subprime refinancing virtually stopped, dropping from 70 percent to zero? Or that subprime mortgage originations would cease, causing further house declines? And that at the same time servicers and banks would refuse to write down principal, leading to more foreclosures and further house declines? And that in the face of so much homeowner misery and the destruction of so much property, the government would wait until March 2009—more than two years after the crash of the subprime ABX index in January 2007—to launch its Home Affordable Modification Program (HAMP)?

5. The Solution to the Crisis: A Multi-Pronged Approach

Once the economy is plunged into circumstances as dangerous as we saw last year, the government has no choice but to act boldly. The correct course of action is to reverse the final stages of the crisis and thus stop the panic. At the outset of this crisis, I recommended the three-pronged approach I present here—a thematic solution to the crisis that addresses in order of importance all aspects of the final stages of the leverage.[29]

[29] See Geanakoplos (2008).

As I explained above, all leverage cycles end with 1) bad news creating uncertainty and disagreement, 2) sharply increasing collateral rates, and 3) losses and bankruptcies among the leveraged optimists. These three factors reinforce and feed back on each other. In particular, what begins as uncertainty about exogenous events creates uncertainty about endogenous events, like how far prices will fall or who will go bankrupt, which leads to further tightening of collateral, and thus further price declines and so on. In the aftermath of the crisis, we always see depressed asset prices, reduced economic activity, and a collection of agents that are not yet bankrupt but hovering near insolvency. How long the aftermath persists depends on the depth of the crisis and the quality of the government's response. Whether we find ourselves in a similar crisis in the future depends on whether, understanding how leverage got us here, we adopt reforms that require supervisors to monitor and regulate leverage in good times. First, I take up what government actions could have been taken, and in what order, to address the final stage of the double leverage cycle that the government was called on to address in 2007.

The thematic solution once the crisis has started is to reverse the three symptoms of the crisis: contain the bad news, intervene to bring down margins, and carefully inject "optimistic" equity back into the system. To be successful, any government plan must respect all three remedial prongs, and should be explainable and explained to the public in terms that it can understand. Without public confidence, which can only flow from public understanding, any federal government (hereafter, "government") plan undermines its own objectives and limits its prospects for success. The government's actions thus far have not addressed all three prongs adequately and policymakers have thus far largely failed to explain how their various solutions are tied to the roots of the crisis we face.

Unfortunately, the TARP, the government's first intervention plan to buy distressed assets, was not clearly thought through and neither it, the ostensible solution, nor the problem that required a solution were clearly explained. After its announcement, asset prices fell further. But even now, after the panic has subsided, we must ask who or what is the government trying to save? Many in the public have come to believe it is merely trying to save banks, or some big banks, from failure because somehow their failure would signal a catastrophe for the American brand, to be prevented at all costs.[30] The confusion about the government's goals has created its own set of problems, which we can ill afford. Clarifying the government's goals will be harder now, but it remains an indispensible step.

[30] "Sixty-seven percent (67 percent) of adults believe Wall Street will benefit more from the new bank bailout plan than the average U.S. taxpayer." *Rasmussen Reports*, February 2009/56.

5.1 Step One—Addressing the Precipitating Cause of the Crisis: "Scary Bad" News (Massive Uncertainty) about Housing and the Assets Built on Housing

To foster recovery from the dramatic final stage of a leverage cycle as large as the one we have just experienced, the government must address the cause of the uncertainty that triggered the end stage. Without that, the efforts taken thus far to bring margins down and recapitalize banks, even had they been perfectly implemented, would not be enough to reverse the cycle and restore the economy to health. In this crisis, with its roots in housing, that means doing something for housing prices and homeowners. This makes undeniable sense in this crisis, not just because addressing the cause of the uncertainty and disagreement (the scary bad news) is critical to reverse any leverage cycle, but because the biggest social losses will probably come from the displaced homeowners. And, of course, the biggest reason for the tumbling mortgage security prices, and the resulting insolvency of the banking sector, is fear that housing prices will keep falling.

Saving the Homeowners: Stemming the Tsunami of Foreclosures to Come

One of the saddest stories in this financial meltdown is that millions of homeowners are being thrown out of their homes for defaulting on their mortgages. Throwing somebody out of his home is tragic for the homeowner, but also very expensive for the lender. One of the shocking aspects of the foreclosure crisis is how low the recoveries have become on foreclosed properties, after expenses. (Interestingly, the mortgage bond index markets anticipated these bad recoveries.) Nobody gains when the homeowners are thrown out and the banks and/or investors collect pennies on the dollar for the money they loaned. Yet, as we saw, 2 million homeowners have already been evicted, another 2.5 million are seriously delinquent and almost surely will be evicted in the near future, and at least another 3 million will eventually default and be evicted if trends continue. Without much bolder action than has thus far been taken by the government, the stream of evictions and bad recoveries for lenders will continue and accelerate, becoming a torrent that will further depress housing prices and impede economic recovery.

Negative equity is a key driver of mortgage defaults. When faced with an income shock, borrowers who are in positive equity have the option to sell the house rather than default. Borrowers who are underwater (in negative equity) may choose to default even in the absence of an income shock.

The connection between LTV and default is illustrated in Chart 8. For each mortgage in the First American CoreLogic LoanPerformance Data Base, the current LTV is estimated by taking the appraisal value of the house at the moment the first loan was given, and then assuming thereafter that the house changed in value according to the Case-Shiller index for houses with the same Zip code.

As the chart shows, homeowners who have positive equity in their homes default infrequently. But for homeowners with negative equity, the rate of default is staggering. For subprime borrowers with a 160 percent loan-to-value ratio (that is, the ratio of all the mortgages on the home divided by the current home price), the default rate is 8 percent *per month*.

These findings seemed surprising when I first presented them in a *New York Times* editorial written with Susan Koniak on March 5, 2009 (Geanakoplos and Koniak 2009). But nowadays, many other researchers are reaching the same conclusion.[31] The conclusion is an inescapable matter of incentives. It may not be economically rational for a homeowner to continue to pay off a $160,000 loan when his house is only worth $100,000.[32] Mortgage loans have turned out to be no-recourse—after seizing the house, the lender almost never comes after the borrower for more payments. Besides the ability to live in the house, the only other thing the homeowner loses by defaulting is his credit rating, but especially for a nonprime borrower with a low credit rating to begin with, how much can that be worth? Finally, a choice today by a negative equity borrower to default may be moving up in time a necessity to default at some point in the future. In this case, the borrower's credit rating will likely be damaged anyway.

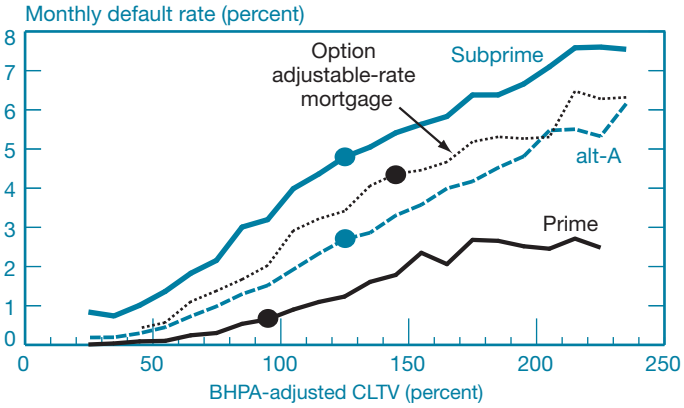
[31] Haughwout, Peach, and Tracy (2008) stress the importance of negative equity as a determinant of early defaults among nonprime borrowers. The Congressional Oversight Panel cited negative equity as the single greatest predictor of default in its report of March 6, 2009. It included the data I provide here as evidence of this fact, data that I supplied to the Panel in advance of its report, as well as data from an array of government agencies, all of which corroborated the Ellington Capital Management data presented here. That is not to say that joblessness is not now having a significant effect on default rates. It is. But even now, negative equity is the best predictor of default and many Americans with jobs are defaulting, and will continue to default, not just the unemployed. See generally the Congressional Oversight Panel's Report of October 9, 2009, on the continuing foreclosure problem and the unimpressive results from government foreclosure prevention efforts taken thus far. Finally, to the extent that job loss has become (it was not at the start of this crisis) a significant cause of defaults, strong effective measures to eliminate the scary bad news—that is, efforts to stabilize the housing market—will help the economy recover faster and thus help the employment rate.

[32] The implication of this statement is that the HAMP plan of reducing interest rates to lower mortgage payments to homeowners who are underwater is, at least for those seriously underwater, an invitation or encouragement to act in a manner that may make no or little economic sense, that is, stretching to make mortgage payments, albeit lowered from their highs, on homes those people will never own when many of them might be able to rent more cheaply.

Chart 8

Monthly Net Flow (Excluding Modifications) from Less than Sixty Days to Sixty or More Days Delinquent

Based on Performance from November 2008 to January 2009 for All Deals Issued in 2006



Note: Circles indicate median combined-loan-to-value (CLTV) ratios by product.

Foreclosures are horribly expensive for the lender. At the present time, subprime lenders collect about 25 cents per dollar of loan when they foreclose. For example, if the loan is for $160,000 and the house has fallen in value to $100,000 and the homeowner defaults and is evicted, the lender can expect to get back $40,000. It takes eighteen months on average to evict a homeowner, and during that time he does not pay his mortgage or his taxes, the house is often left empty and vandalized, a realtor must be hired to sell the house, and so on. Of course, the main reason the average recoveries are so low is that the defaulters are the homeowners who are furthest underwater (see Chart 8).

In a rational world, many foreclosure losses would never happen. The lenders would renegotiate the loans by reducing the principal so the homeowners could pay less and stay in their homes, and the lenders would actually get more by avoiding the losses from legal fees and bad home price sales. If the above loan were written down to $80,000, the homeowner would likely find a way to pay it, or else fix up the house and sell it for $100,000. Either way, the lender would get $80,000 instead of $40,000. That would have the further benefit of keeping many homes off the market and thereby aid in the stabilization of home prices.

The Home Affordable Modification Program pays servicers to temporarily reduce interest payments and to extend the term of the mortgage in order to reduce the monthly payments on the mortgage, but does not incentivize servicers to cut principal. Cutting monthly payments by half will temporarily reduce the homeowner's payments by the same amount that cutting principal by half would. But under the government's plan, the

cut is temporary, not permanent, and thus is likely to lead to many more defaults in the long run than cutting principal would as soon as the interest rate goes back up.[33] In fact, since the homeowner will still be underwater, he will not in any meaningful sense own his house. He will be less likely to make repairs, he will not be able to give the house to his children, he will not be able to sell it if he gets a job in another city.[34] In short, there is every reason to think he will likely default even before the interest rate goes back up. For loan modifications where there is no principal reduction, the redefault rate is above 50 percent within nine months.[35] Indeed, because the government's present plan allows servicers to increase principal while cutting interest by adding fees and other costs to the old principal amount, the plan is likely to leave more homeowners underwater than there would be absent the plan and others more deeply underwater—that is, with even less chance of ever owning their homes and thus less incentive to keep up with mortgage payments—than they would have without this government "rescue" plan.

HAMP started off slowly and only recently is beginning to be able to process a larger flow of mortgages. In the first six months of the plan, according to the Congressional Oversight Panel's October 2009 report, only 85,000 mortgages had been modified, and of those only 1,711 were "permanent" modifications (that is, permanent/temporary, since interest rate reductions under the plan are designed to end in a few years), and of those only 5 involved principal reductions.[36] As of May 2010, HAMP had started trial modifications on 1,244,184 loans, of which 429,696 had been canceled and 340,459 had been converted into permanent modifications. Again, virtually none of the permanent modifications involved principal reduction. Of the 5.7 million loans that were delinquent sixty or more days in May, only 1.7 million were eligible for HAMP modifications.

[33] Haughwout, Okah, and Tracy (2009) find in a sample of pre-HAMP subprime mortgage modifications that reducing principal is twice as effective as cutting the interest rate in terms of reducing the post-modification redefault rate.

[34] See Gyourko and Saiz (2004).

[35] See "OCC/OTS Mortgage Metrics Report," 2Q 2009.

[36] To be clear, my criticism of HAMP is not based on the number of the time-limited "permanent" modifications completed, but rather is centered on the near-exclusive concentration on interest reduction and, as I explain in the text below, on leaving the servicers in charge of the modification decision. I could find no updated information in the report on how many, if any, of the trial or permanent modifications involved principal reduction as opposed to interest reduction, and I have no reason to assume that the percentage of modifications with principal reductions has increased. It is also worth noting that in the Congressional Oversight Panel's Report of October 2009 (p. 127), the Panel notes that the apparent rise in modifications due to the administration's plan might be overstated, as there was some evidence of a "substitution effect," that is, the number of "voluntary" modifications by servicers (or modifications made outside of the administration's plan) went down in the first six months of the plan, suggesting that the gross number of modifications attributable to the plan itself might be exaggerated. The new report by the government does not provide data from which one can assess any substitution effect.

The design of any modification program must recognize that the servicers have incentives that at times put them at odds with bondholders and homeowners, so that they may actually prevent modifications that would help lenders and homeowners but hurt servicers. In the case of many nonprime borrowers, the loans have been pooled in a trust, and their principal has been tranched into many different bonds, each held by a different investor. The lenders are the bondholders, but they are numerous and dispersed and by contract have given up the legal right to renegotiate with homeowners, delegating that right to an agent.[37] That agent is the servicer, who has a fiduciary responsibility to act in the interests of the bondholders in the trust.[38] In "normal" times, this arrangement worked tolerably enough. But in this crisis, with so many mortgages in or near default, it has failed miserably for at least four reasons, all traceable to a misalignment of interests between servicers and those whose interests they are supposed to protect, which has now ruptured with terrible effects.

First, modifying loans is a time-consuming and expensive operation. The servicers who have the legal right to make modifications do not get paid directly for improving the cash flows to loans. It is generally cheaper for them to move into foreclosure. In particular, they have no incentive to set up the huge infrastructure and to hire and train the extra staff required to make sensible modifications on a grand scale.

Second, modifying the loans has different effects on different bondholders. It has proved difficult to modify loans in a way that pleases everyone. The servicers say they are terrified of lawsuits from the bondholders if their modifications help most bondholders but hurt others. For example, writing down principal immediately may make more money for the trust as a whole, but it would immediately wipe out the BBB bonds and possibly other lower level bondholders. Letting the borrowers remain in their houses without paying during the foreclosure process means that during all that time all the bondholders, including the BBB, get their coupons paid in full from servicer advances. The servicers then recoup their advances, at the expense of the trust, when the house is finally sold.[39] In reality, servicers

[37] It should be noted that this right was given up to avoid the collective action problems inherent when the lenders are numerous and dispersed, and thus was given to a third party (the servicer) to be exercised on the lender's behalf, the servicer acting as a fiduciary for the lenders. It was not given to the servicer to be used to benefit the servicer's interests at the expense of the principals (the lenders), and using the discretion to modify or foreclose that way is self-dealing on the part of servicers and a breach of their obligation to the lenders.

[38] See Alan Kronovet, "An Overview of Commercial Mortgage Backed Securitization: The Devil Is in the Details," 1 N.C. Banking Inst. 288, 311 (1997), explaining fiduciary duties of servicers. Section 1403 of the new housing bill that was signed into law on July 30, 2008 (HR 3221, the Housing and Economic Recovery Act of 2008, P.L. 110-289), lays out the fiduciary responsibilities of servicers of pooled mortgages.

[39] This requires that the servicers have access to capital to finance the coupon payments until the foreclosure process is concluded.

were not deterred only by potential lawsuits. That was revealed when Congress passed legislation that freed servicers from lawsuits by bondholders.[40] Principal reduction modifications did not follow. To put it all another way, there is a complex negotiation that is not taking place, and the government needs to intervene to break an impasse for the public good.

Third, now that HAMP, which is based on interest reductions, has given the servicers cover to reduce interest instead of principal, they can be counted on to do the former and eschew the latter. Cutting the principal by half, for example, immediately reduces the servicer's fee by half (since the fee is computed as a percentage of principal), while cutting interest does not. Moreover, cutting principal increases the likelihood that the homeowner will sell or refinance, which would cause the servicer to lose his fee entirely.

Fourth, the biggest servicers happen to be owned by the biggest banks, which in turn own a huge number of second-lien loans. Cutting principal on first loans almost implies cutting the principal drastically, if not to zero, on second loans. But that would mean that the banks could no longer hold the second-liens on their books at potentially inflated prices. The banks want desperately to postpone the write-down of those second-liens, which is to say, they have yet another powerful motive not to do what is in the interest of lenders, homeowners, and the economy as a whole: reduce principal on the first-lien loans they are servicing. By contrast, cutting interest on first-lien loans makes it easier to justify carrying the second-liens on bank balance sheets at higher values for the near term (which is what matters to the banks), as homeowners are more likely to be able to make the lower monthly payments (from lower interest rates) than their original payments, at least in the short run.[41]

Another indication that servicers have bad incentives is that when the big banks hold the same kind of loans in their private portfolios, they do reduce principal. During the second quarter of 2009, 30 percent of all modifications done to loans directly held in bank portfolios involved some principal reduction. During that same quarter, the servicers reduced principal on 0 percent of their loan modifications, as did the government-owned agencies Fannie Mae and Freddie Mac.[42]

Loans that have not been securitized and are held entirely by banks (whole loans) are also not being written down fast or far enough.[43] The pathology this time is, if anything, more distressing. It appears that the banks, abetted by the suspension of mark-to-market rules, are unwilling to fully recognize the losses that have occurred on their residential mortgages.[44] They may prefer to keep a mortgage on their books at $160,000, even though it will eventually bring them only $40,000, than to reduce the principal to $80,000 and mark the loan at this value today. The suspension of mark-to-market rules has also fed the pathology discussed above on second-liens. Perpetuating a conflict between the economic value and the accounting value of an asset is bad government policy when it leads to actions that further reduce the asset's value. This conflict is also obscuring the value of bank assets, many of which are being guaranteed by the government, and thus in turn obscuring the value of mortgage assets now owned by the government. In my terms, this only ensures the continuation of "scary bad" news (uncertainty), when the goal should be for government plans to clarify the situation (the value of assets) that keeps leverage severely constricted.

Insuring that economically efficient mortgage modifications are made for borrowers can be greatly facilitated by placing the decisions with impartial agents. In October 2008, Susan Koniak and I urged the government to take the reworking process out of the hands of the servicers and put the decision into the hands of government-hired trustees. In our approach, the government-hired trustees would be told only about the homeowners, and would be blind to the bonds built atop the loans. Their job would be to choose modifications or foreclosure, whichever they judged would lead to the greatest recovery *for the lenders* on the original loan. They would thus be carrying out the duties of the servicers exactly as they were intended, but free from the conflicts of interest and perverse incentives that have prevented the servicers from carrying out their mission.[45]

If there is a second-lien loan, the government trustees would make the same calculation, deciding what modification, if any, would maximize total revenue. If this involved reducing principal, then the second-loan principal would be reduced to

[40] See Section 201 of the Helping Families Save Their Homes Act of 2009, preventing lenders/bondholders from suing servicers who modify mortgages under a qualified mortgage modification plan, which is defined in the Act broadly enough to include all economically sensible modifications, that is, those with a reasonable prospect of returning more money to the lenders than a foreclosure.

[41] Cutting the monthly payments will also push the likely default further into the future. Under current accounting rules, this reduces the loss reserves that the banks have to hold against these loans.

[42] See OCC/OTS Mortgage Metrics Report, Q2 2009.

[43] At first, it appeared that they were not being written down at any greater rate than securitized loans, although the data are not perfect on this. Foote et al. (2009) argue that this showed there was no real incentive to write down loans. Now, again based on imperfect data, there seems to be some evidence that principal on whole loans, at least at some banks, is being written down more often than principal on securitized loans (which effectively never see reductions in principal), although reductions in principal on whole loans are still much less frequent and much less widespread than one would expect to see given the economics of the situation, that is, that reducing principal for many underwater homeowners will yield much more money than foreclosure or (over the long term) interest reductions.

[44] Banks may also still be holding out for some more direct government subsidy for their failing whole loans, either through government assumption of the mortgage risk or some other form of direct payment for anticipated whole loan losses.

zero. The second-loan holder could still receive some cash, however. I would recommend distributing the same percentage of the monthly payments to the second loan as it was getting before principal was reduced for a period of, say, two years. After that, the second loan would be completely extinguished and all cash flows would flow to the first-loan holder.

For a vast number of homeowners now upside-down in their mortgages, that is, owing more than their home is presently worth, this process would likely result in a reduction of principal. Why? Because reducing principal rather than cutting interest rates would be more effective at preventing defaults and would yield investors/lenders more money than foreclosing, as we have seen.[46]

If the government handled this correctly, most homeowners who were unable to pay the original loan but were willing and able to pay a modestly lesser amount would get to stay in their homes, the bondholders collectively would get more payments than they are currently expecting (though some tranches would be hurt), and the government would not have to invest any capital.

This plan is not the same as "cramdown" in bankruptcy, which Congress has thus far rejected and which entails costs and creates some perverse incentives that my plan avoids. Giving reductions in principal through bankruptcy (assuming the law were changed to allow that) would encourage homeowners now current on their mortgages but underwater and thus likely to default sometime in the future to default immediately to support their petition for bankruptcy relief. However, my plan, as originally conceived, does not build in any incentives for the borrower to default in order to increase the chance that the mortgage will be modified. Principal reductions would be done first for homeowners who have not defaulted yet, and only later for homeowners who have defaulted under some special hardship. It would give underwater homeowners now holding on for the short term a continued incentive to keep paying until the government trustees could evaluate their loans and circumstances for a reduction in principal. Second, my plan differs from bankruptcy in that it does not subject homeowners to the shame and devastating harm to future credit and thus to their economic circumstance that a bankruptcy proceeding entails. Third, my plan contemplates putting local housing market experts and community bankers in place as government trustees, not bankruptcy judges who are neither numerous enough to handle the number of defaulting homeowners who should justifiably qualify for principal reduction nor as knowledgeable as the personnel I would put in charge.[47] If my plan were indeed up and running, bankruptcy might be something worth considering as a true last resort for those already deeply in default. Finally, bankruptcy involves all kinds of hidden costs, like lawyer fees and trustee expenses (on top of the costs associated with the experts required to advise the bankruptcy judges) that are unnecessary and wasteful for the vast majority of homeowners and lenders who should be able to make a win-win deal without incurring those costs.[48]

My original plan called for legislation to cut through the agency-problem mess in securitized pools of mortgages by eliminating contract provisions in pooling arrangements that now enable servicers to act contrary to the interests of the investors that the provisions were originally designed to protect. Thus, I envisioned that the government trustees would only be empowered to modify securitized mortgages. This would leave unsolved the problem of whole loans that banks are still refusing to modify sensibly, by writing down principal for underwater homeowners.

I believe, however, that once a government program of modifications for securitized loans proved its worth by resulting in more recovery for investors, banks would be likely to adopt similar standards to modify whole loans. Nonetheless, a solid government plan to force sensible principal reductions for securitized loans would, I believe, go a long way toward convincing the banks that no better deal from the government was forthcoming, particularly if the government clearly articulated that this was so, and would exert discipline on the valuation of the whole loans and second loans on the banks' balance sheets. Obliging the banks to mark to market would, of course, also push them to get the most value out of their loans by writing down principal for underwater homes.

Finally, what if home prices vastly appreciate by the time the homeowner sells his home? To prevent unwarranted windfall profits to homeowners, the government plan could easily require the homeowner to share 50/50 with the lenders any appreciation in home price up to the full amortized value of the original mortgage, and the plan might even provide that, for houses sold for more than the original loan price, lenders receive a greater percentage of the appreciation.

[45] See Geanakoplos and Koniak (2008). Under this plan, the servicers would still collect the servicing fees they do now. They would continue their duties of sending letters to homeowners, collecting the monthly payments and distributing them to bondholders, evicting homeowners who did not pay, selling their homes, and so on. The only change is that the mortgage loan modification would be taken out of their hands and put into the hands of the government trustees. This reassignment of a particular duty in the contract is not a "takings" from the servicer, among other reasons because the servicers have failed to carry out their fiduciary obligations to the bondholders who employ them to get the most possible value out of the loans. See Dana (forthcoming).

[46] See Haughwout et al. (2009) for evidence based on subprime modifications.

[47] Indeed, it is highly doubtful that our bankruptcy courts could handle the job Congress would be giving them if so-called cramdown legislation were adopted, at least not if it were adopted without first having a plan like the one I propose up and running to handle the vast majority of underwater homeowners.

[48] My plan envisions the government paying for the trustees (community bankers) to decide on whether principal modification would bring in more for bondholders than foreclosure, but I estimate that government expenditure should come to less than $5 billion.

A Floor to Housing Prices and Restarting Private Lending on Mortgages: Government Equity Stake in Homes

There are at least four reasons to support housing prices directly, in addition to doing so through effective foreclosure relief. First, if housing prices held firm, fewer homeowners would be underwater; thus, more would have an incentive to make their payments. That would keep them in their homes. Second, firm housing prices would staunch the losses on mortgage securities even if there were foreclosures. Third, once there is a floor to housing prices, pessimistic lenders would be relieved of the disaster scenario for many mortgage securities, and margins on mortgage securities would come down significantly, enabling optimistic buyers to purchase them using leverage, pushing up the price of mortgage securities.[49]

Fourth, the leverage cycle is less severe for housing than for mortgage securities, so it can be fixed more easily by government intervention, because home buyers generally lock in their loans and leverage for the duration of time they live in the house. Only new buyers of homes, and those who want to change homes, need to confront the tougher margins. Existing homeowners cannot be forced to put more money down, whereas mortgage security holders who borrowed on one-day repos have found that they now face tougher margin requirements that involve putting more money down. Thus, there are fewer homes in play than there are mortgage securities.

The government has recognized the need to try and support housing prices. A concern is that the measures taken will expose the government to the risk of billions of dollars of future losses, in addition to substantial current costs, while leaving private mortgage lending dead in the water. We simply cannot sustain a situation where all mortgage lending is done by the government. The plan I propose helps to stabilize housing prices and to reinvigorate private lending. And in the long run, it may cost the government much less, possibly even making money.

Current government FHA policy is to make mortgage loans with as little as 3.5 percent down. In addition, borrowers can finance some of their closing costs as well as the up-front mortgage insurance premium. As a result, the effective LTV on new FHA mortgages can exceed 100. These homeowners start with little incentive to continue making payments, particularly in rough economic times. Given the transaction costs of selling a house, absent a rise in housing prices these borrowers will remain underwater and thus create a new source of future defaults. This policy is a repetition (albeit on a smaller scale) of the low down payment lending practices that got us here. It exposes the government to a huge risk of default, and does nothing to stimulate private mortgage lending.[50]

The government has also tried to stabilize housing prices through its efforts to keep mortgage interest rates low and thereby encourage purchases and refinancing. To this end, the Federal Reserve's Large-Scale Asset Purchase program has purchased $1.25 trillion of agency mortgage securities. Like the HAMP modification program, this choice reflects once again a concentration on interest rates rather than on the collateral (leverage) effects that are at the core of my argument. The Large-Scale Asset Purchase program appears to have lowered mortgage interest rates, but surprisingly few homeowners were able to take advantage of the lower rates by refinancing because they could not come up with a down payment and/or their credit had deteriorated.[51] One might worry that as the purchases wind down, mortgage rates may go back up.

A third government initiative is to give an $8,000 tax credit to buyers of homes. This tax credit does appear to have been more successful at stimulating home purchases. But the tax credit has no upside for taxpayers and it does nothing to reinvigorate private lending since most of the new mortgages were guaranteed by the FHA. If $8,000 were spent on 7 million homes, the cost to taxpayers would come to $56 billion. By contrast, the equity stake plan I propose below is a purchase of value for value; in the long run, it may cost nothing and actually have upside for taxpayers. It should also stimulate demand, and it would reinvigorate private mortgage lending.

As I observed earlier, toughening margins have affected housing prices, because many homeowners can no longer put up the cash payment needed to buy new homes. New homeowners are being asked to put as much as 30 to 40 percent down if they cannot get a government loan. The government could stimulate demand for new purchases, and also mitigate the margin problem, by offering to buy a 20 percent equity stake in any new home purchase (under some maximum price, as with agency conforming loans). Thus, suppose a house is purchased for $100. The government pays $20 and gets a 20 percent equity piece, which it collects whenever the homeowner sells. If down the line, the house sells for $200, the government gets $40. The government is thus earning the home price appreciation on its piece, without having to bear the expense of maintaining the house. The homeowner gains

[49] As I discuss below, margins must in the future be monitored by the Federal Reserve to assure that they do not once again get excessively low, precipitating another massive and dangerous leverage cycle.

[50] For more on FHA risk, see Aragon et al. (2010).

[51] See Caplin, Freeman, and Tracy (1997) for a discussion of down payment constraints on refinancing and Peristiani et al. (1997) for a discussion of credit constraints. To address this concern, the administration started the Home Affordable Refinance Program, which allows borrowers with prime mortgages to refinance with current LTVs as high as 125. In addition, the FHA introduced a "streamline refinance" program for borrowers with high-LTV FHA loans to refinance to a new FHA loan.

because he gets to live in the whole house while paying for only 80 percent of it. If the home buyer needs a loan to get the house, the government equity piece reduces the down payment the buyer must make, and the ongoing mortgage payments he must make. And if we make the government's equity piece the second loss piece, it leaves the lenders in a very, very safe position, encouraging lending. In effect, it lowers the margin to the borrower, and raises the margin of safety to the lender. Here is how it works.[52]

Under the plan, the home buyer who wanted a loan to purchase the house would be allowed to borrow at most 80 percent of the $80 of the house he bought, or $64. He would have to put up 20 percent x $80 = $16 of his own cash. The homeowner would then have a big incentive to make his payments. If he walks away from his debt, he can save $64, but he has to give up living in a $100 house on which he had an $80 ownership share. But if the borrower does default, and if the lender has to foreclose, the lender would be able to collect his debt out of the house sale proceeds ahead of the government equity piece. The government would collect next, and lastly the buyer would get any leftover cash. If the house sold in foreclosure (net of expenses) for $82, the lender would get his $64, the government would get $18, and the homeowner nothing. The effective margin for the homeowner is thus 16 percent on the asset price of $100, but the margin of safety for the lender is 36 percent. This should make the lender feel very safe and encourage private lending on mortgages. The homeowner's down payment of 16 percent on the total home price is about half the down payment many nongovernment lenders are demanding now. On top of that, the new buyer's mortgage payments would be 20 percent lower than before, because he would be paying on a loan of $64 instead of $80.

What about the costs of my plan? Last year, there were 5.5 million new home purchases, down from a high of 7 million. Even if the government had to buy the equity in the entire 7 million, at an average home price of $200,000, it would cost $280 billion. But the government would own equity, and be protected by the homeowner's down payment. Housing prices would need to fall another 16 percent before the government lost equity value. As housing prices stabilized, the government would gradually phase out the program, in all likelihood in a year, at most two, after adoption. To lower the government's overall equity investment, the program could be limited to first-time home buyers.

[52] Equity sharing arrangements could also form with private investors. For a discussion, see Caplin et al. (1997).

5.2 Step Two—A Fed Lending Facility to Help Restore Reasonable Leverage

The most easily implementable step and the second priority, after addressing the source of the uncertainty (the scary bad news), in responding to the final stage of any leverage cycle could be government action to decrease astronomical collateral rates. Thus, in October 2008 I suggested that the most immediate step the Federal Reserve could take was to lend money using the so-called troubled assets (those that suddenly became nearly impossible to use as collateral, as I explained earlier) as no-recourse collateral. I suggested 50 percent margins on average, a reasonable halfway level between the 5 percent margins required at the peak of the leverage bubble and the 70-90 percent margin rate demanded in 2008. The Asset-Backed Securities Loan Facility (TALF) and the Public-Private Investment Program (PPIP), announced in early 2009 at what turned out to be the bottom of the price cycle, embody the spirit of my recommendation. Indeed, the PPIP did lend on these bonds at exactly 50 percent margins. The turnaround of prime mortgage security prices (displayed in Chart 2) after these programs were announced seems to me to be some evidence for the wisdom of the intervention. But in terms of some important details, those programs did not go as I would have recommended. In any case, it now appears that having achieved their purpose, they have been drastically attenuated.

Lending with smaller margins (haircuts) than the market is willing to offer to borrowers who might not repay is a great departure from the traditional role of the Federal Reserve. The orthodox view is that the Fed injects liquidity into the system by lending money to banks and others with impeccable reputations for repaying so as to reduce the riskless rate of interest on very short-term loans. The banks would then presumably turn around and relend that money to investors, at a lower interest rate than would have obtained absent the Fed's intervention. However, the great bulk of lending in the investment world is not based on the reputation of the borrower but based instead on the value of the collateral. The lesson of the leverage cycle is that when lenders demand too much collateral for their loans, liquidity dries up. The Fed cannot undo this by making riskless loans at a lower interest rate than the market, because in liquidity crises it is not the interest rate the banks charge that impedes investor borrowing but rather the amount of collateral they require. The Fed needs to step around the banks and make risky loans directly to investors with smaller haircuts than the market demands, if it is to have the desired effect.

The mechanics of such a massive lending program require some careful thought, but nothing compared with the

difficulties of directly buying. The Fed could simply announce that any arm's-length buyer of any designated security could, at the moment of purchase, take that security to the Fed and receive a five-year loan of 50 percent of the price in exchange for putting the security up as collateral. The Fed would not need to price the security itself. The market would have just done the pricing. With a 50 percent margin, the government money is still quite safe. Remember, the 50 percent loan is against the price the securities will be traded at, not against the original price when issued. The government could thereafter monitor prices, periodically demanding more cash from the borrower to maintain its 50 percent margin, which would make the government lending safer and more responsible.[53] Monitoring the collateral price is a much easier job than deciding the price to buy, since there is a 50 percent margin of error: the price monitoring only has to be half right. And the government could consider charging a slightly higher interest rate than the fed funds rate or discount rate, thereby potentially making a profit for taxpayers. That would also make the program easier for the public and politicians to accept.

Needless to say, the 50 percent margin cannot be applied to all bonds. Some bonds have such high volatility in their cash flows that even a 50 percent margin is unsafe. Other bonds can safely be leveraged much more. The Fed must exercise its own expertise in setting these margins, as I discuss later. But in a crisis, they should be set at levels substantially more generous than the market is offering, and significantly less generous than the market had been offering in the ebullient stage before the crisis.

The five-year term can also be chosen flexibly. But it is important that there is a longish term commitment to borrowers that the loan will not be pulled from under them. The last thing a buyer wants to do in a crisis is leverage to buy and then have his financing pulled, or his margins increased. Of course, the Fed needs to worry about its exit strategy; if it lends too much money long term, it will not be able to reel it all back in should inflation pick up. However, by lending at margins and interest rates that are favorable in the crisis but that borrowers will find onerous once markets pick up, and by making margin calls, the Fed can count on most borrowers refinancing their loans privately once the market heats up.

The government might even arrange all this lending without having to come up with the money. Under this alternative, the government could loan slightly less, say, 40 percent, and give up the right to make margin calls. The loan could then be securitized, guaranteed by the government, and sold off to the private sector. With the government guarantee, the money would easily be raised. Or even more directly, for some bonds where this makes sense, the government could simply guarantee a certain percentage of the principal payments. Private lenders could then lend this much without any risk of default. Of course, on some securities the government might be able to lend much more than 40 percent and still regard the money as safe.

At 50 percent margins, buyers would be able to purchase securities using only half the cash they need to put up at the bottom of a cycle when margins might become 100 percent. Aside from allowing investors' own cash to go further, this borrowing allows investors to earn leveraged returns. If they think the security trading for 60 might only rise to 66 in the near future, they can buy it with 30 down and earn a return of 20 percent when it rises to 66 instead of a return of 10 percent. Buying will be stimulated and the depressed prices at the bottom of the leverage cycle will be pushed back up. Again, with this potential for private profit, the program would make more political sense if a somewhat higher interest rate for the loans were charged, thus building in a real chance for taxpayer profit.

Lending is better than the government's first (and quickly shelved) idea, as proposed by former Treasury Secretary Henry Paulson, of buying up the "troubled assets." As I explained in October 2008, lending against collateral does not require the government to choose what prices to pay, as it would have to if the Treasury directly bought securities. Moreover, lending, unlike buying, is direct action to restore leverage and restoring leverage is the thematic solution to the leverage cycle crisis. It is not some stop-gap band-aid invented only under the pressures of the moment.

Further, lending puts taxpayer money at far less risk than buying does. Assuming the Fed lends at 50 percent margins, every dollar the government lends using the targeted assets as collateral will necessarily be matched by money the investor spends on those assets. The government can say its money is being leveraged. The investors who avail themselves of the government lending will still have their money at risk. Because these investors, and not the government, will do the buying, there is little, if any, chance that this action will push prices to outrageous levels and enrich undeserving sellers.

The Fed has boldly gone a long way in this direction, further than any previous Fed. Through the TALF and the PPIP, the Fed and the Treasury, respectively, have indeed embodied many of these ideas. The PPIP lends at 50 percent margins on troubled mortgage securities, just as I recommended. Its announcement, I believe, played a pivotal role in starting what is now more than a year-long rebound in security prices. Given the condition of the asset markets in early 2009, the rebound in prices seems almost miraculous, and in many ways one must judge the TALF/PPIP a resounding success.

Nevertheless, I believe that the Fed-Treasury leverage intervention would have been better if it had been implemented somewhat differently. This difference is

[53] Even if the securities gradually lost all their value, the Fed would still not lose any money if it made frequent margin calls.

important to bear in mind not just for this crisis, but also in case there is another crisis in which prices do not rebound as quickly after a leverage intervention. In my opinion, the two programs did not encompass a wide enough set of assets or a wide enough set of borrowers, they took too long to get going, and in some cases TALF actually took leverage up almost to the crazy levels it had been before. Had TALF started earlier, and had it lent on more assets, it would not have been forced to give such high leverage on the narrow band of assets it did lend against.

In the emergency stages of the leverage cycle, the Fed should have extended lending on more kinds of collateral. TALF restricted leverage mostly to new securities, or to securities that were still AAA-rated. As more and more mortgage securities get downgraded below investment-grade status, they lose their ability to be used as collateral even in the private sector. Lending against the most toxic securities is actually necessary to maintain their value.[54]

The TALF program made government loans on new credit cards, auto loans, college loans, and other securitizations at 20 to 1 leverage. In my opinion, this repeats the error of the FHA mortgage program, lending at the same inflated leverage that got us into trouble in the first place. The Fed has rightly observed that propping up new security values is more important than propping up legacy security values, because new securities represent new activities. When new prices go down, new securities are not issued and the underlying activity for which the securities would be issued (students going to school, cars being purchased, new houses being built, consumers buying with credit cards) stops. However, as I argue more formally in Geanakoplos (2010), in the depths of the leverage cycle, the Fed could raise the price of new securities further by leveraging them less, if it would also leverage the legacy securities to modest levels. The reason is that potential buyers of these new securities are tempted instead to put all their capital into the depressed legacy assets where they are nearly sure of a high return. This indeed is one of the main reasons banks stop lending to businesses or homeowners: they can get better returns by buying depressed legacy assets. Given the depressed legacy security prices, the only way TALF could redirect this private money into new securities was by giving leverage on the new securities at astronomical 20:1 ratios. If instead the Fed would give much lower and safer 2 to 1 leverage on the legacy assets, it would raise the legacy asset prices, and thus even the new security prices, because it would remove the bargains investors are seeking in the legacy assets.[55] The new assets would not need so much leverage, and the risk to the taxpayers would be reduced. This would also go a long way to solving the bank lending problem. As I show again in Geanakoplos (2010) (in a stylized example, to be sure), despite lending on a much larger scale, by allowing leverage at 2 to 1 on a wide array of assets rather than at 20 to 1 on a narrow set of assets, the Fed could actually reduce its expected defaults while increasing the prices of all the securities. A year later, it now appears that the Fed will not face significant losses on these TALF loans, and private leverage is also returning. But had things gone worse, the Fed might have been stuck with some dangerous loans.

In the crisis stage, the Fed needs to go around the banks and lend directly to more investors. In theory, the Fed could make no-recourse loans only to a few banks, who would turn around and relend to everyone else. But the banks are nervous about showing too much lending on their books, they ask for too much collateral, and now the Fed is giving them more profitable ways to make money than by lending; so the Fed must reach out directly to more borrowers. Curiously, the PPIP has been restricted to ten potential borrowers/investors, making its scope and size in the end less than what was anticipated. Also, with only ten investors taking government money, the potential for conflicts of interest seems very high, as I discuss later.

The TALF and PPIP programs took too long to get up and running. Hopefully, at the bottom of the next leverage cycle, or even earlier, similar programs could be implemented sooner. I recommend that the Fed keep a standing, permanent lending facility up and running. In normal times, it would lend a little bit across a wide range of assets, to be ready to spring into action if private collateral rates became too high. This facility could be administered directly by the Fed, by people it hired, or it could be run through the repo desks of the Wall Street banks. In the latter case, it would be wise to insist that the banks put some of their capital at risk along with the Fed money. The advantage of using repo desks is that they are already staffed with trained personnel, who have great expertise in making margin calls. Duplicating that expertise would be expensive.[56] The advantage of a permanent facility is that the Fed would be ready to quickly lend on a grand scale, on many securities, and to many lenders, in the next crisis.

[54] Again, such lending would be much less risky if the government had adopted a sensible plan to staunch foreclosures and stabilize housing prices, such as I have just outlined, because such a plan would reduce the toxicity of the securities at issue. And the quicker the government moves to do that, the less risky such lending will become, not to mention the good it would do for the value of the toxic securities the government now owns through one program or another or now guarantees, representing continuing and enormous government money still at considerable risk. This point is why I stress the importance of understanding the nature of the crisis in crafting sensible solutions and how failing to address one part of the problem, in our case the failure to adequately address housing, limits the good that otherwise sensible programs might make.

[55] Another reason why it actually could raise new security prices is that by leveraging the legacy securities at 2 to 1, it will free some investor equity to put into the new securities.

[56] I presented this proposal for a lending facility to the Liquidity Working Group at the Federal Reserve Bank of New York in early 2009.

5.3 Step Three—Restoring "Optimistic" Capital

Lending will not by itself bring the prices of assets to their old levels (which is okay, given that "old" values were inflated by excessive leverage, as I have explained). But that means that the most optimistic buyers, unfortunately including some of the biggest and most prominent financial institutions in America, have irretrievably lost a huge amount of capital. Not only is their capital no longer available to spend on these securities, but similarly the money they borrowed to spend on these securities has also disappeared.

The most obvious thing the government could do, it did: inject money into financial firms. The idea was that then the firms would continue to function as optimistic buyers and their workers would not join the ranks of the unemployed. But the main problem with the way the government injected capital is that this injection of capital was not coordinated with vigorous programs to address the two other prongs of the end of any leverage cycle: the source of the scary bad news (here, housing) and the precipitous drop in leverage, which I have just addressed in my discussion of Fed lending.

In the absence of vigorous programs to address the first two prongs of any leverage crisis, injecting capital does nothing but push an ultimate reckoning down the road. Without steps one and two, the true financial status of our financial institutions is unknown and unknowable because there is no reliable way to price many of the assets they hold. The danger is that the injection of new capital keeps the banks from failing immediately, but it is not enough to restore their previous activities, leaving them in a kind of limbo and actually creating more uncertainty in the system about whether they will survive. As long as no one knows whether and to what extent our biggest financial institutions are sound, our economy cannot recover.

Bailouts with Punishment

After a double leverage cycle as outsized as we have just been through, it is likely that even with a lending facility established, and capital injected properly into the system, some, maybe many, firms would still fail. In general, that is what we should want. The government cannot afford to make good everybody's debt. Some debtholders must lose when a financial system is allowed to become bloated by artificially high prices maintained by excess leverage from the ebullient stage of the leverage cycle. In the ebullient phase of this cycle, too many people were drawn into the financial sector by the resultant artificial profits. Failures will remove many of these excesses.

But what if those institutions are seen by the government as, in current jargon, systemically important? For those firms, the Treasury might want to intervene, as the Fed did last year, on a case-by-case basis. But, if that approach is used, important issues are the degree to which the shareholders have to give up their shares and the bondholders lose their value, and whether new management should be put in place. Even in cases where old management is not that old, that is, cannot be reasonably charged with responsibility for all the excess, replacing management may be wise, if only to help bolster public support for the government's actions and expenditures of taxpayer funds. It is also imperative that the government decide as quickly as possible after a crisis presents itself (and on grounds that can be explained as fair and objective), who it will let fail, and then coordinate an orderly liquidation. Quite possibly the biggest public relations risk the government runs in the bottom of the leverage cycle is to appear to be bailing out ailing firms on too generous terms.

If instead of injecting funds into an ailing firm the government takes it over, it must quickly decide what it will do with the creditors. Once it guarantees their debts, there is no turning back when the full extent of the firm's asset value becomes clarified. In the case of AIG, it now appears that the government will lose much less money than was initially feared. But in the case of Fannie Mae and Freddie Mac, where the stakes are orders of magnitude bigger, we still do not know what the government losses will be. It is conceivable they may approach $1 trillion, though that does not seem likely at the moment. This is another reason why steps one and two are urgently needed at the very outset of the crisis to clarify prices.

Government Purchases of Assets

The government could replace the lost optimistic capital by buying distressed securities directly. In effect, the Treasury would take conservative and pessimistic taxpayers' money that would never be invested in these securities, and invest it there, assuming, of course, that it did so with the expertise necessary to make reasonably sound judgments on which securities to buy and how much to pay for them. This was the plan that Secretary Paulson originally proposed.

Government buying plans are a risky approach—riskier than the steps I have laid out above—and thus, if ever used, must be implemented with extreme care. An argument that is often blithely made for government buying is that when security prices are terribly depressed in "fire sales," the government might make some good investments. It is likely, the argument goes, that the general taxpayer is too conservative, and by transforming pessimistic capital into optimistic capital, the government might even be directly helping the taxpayer, while at the same time staunching the collapse of security prices.

Forcing natural pessimists into purchases they fear, however much potential financial upside, may well undermine public confidence in government, especially if the investments start to go bad. But even if taxpayers were on board, caution should be the watchword. The lending mentioned earlier (a much more direct approach to restoring leverage) would probably raise security prices, so the government purchases would not be at rock-bottom prices. Private investors (naturally more agile and quicker than the government), knowing that the government would be buying, would rush to buy first, reducing potential government profits. Of course, that, in some sense, would be what the government would want to happen because it would mean that security prices would rise more quickly. But it might also result in taxpayers getting stuck with the worst assets, causing public outrage and charges of foul play.

The biggest obstacle and the one that apparently stopped Secretary Paulson's original plan to buy the troubled assets is the enormous challenge of deciding what to buy, and at what price. We must not forget that the downward swing in the leverage cycle is always triggered by genuine bad news, which I call scary because it creates more uncertainty. Private investors hold back for fear of "catching a falling knife"; the government has far less expertise than these private investors. Since the distressed mortgages are very heterogeneous, it is not at all clear how the government acting alone could figure out what prices to pay. Indeed, since Secretary Paulson's call for government purchases of distressed securities, a large number of them (including most CDOs) have continued to lose value, with some even going to zero. In retrospect, a program of indiscriminate buying might have been a disaster. But how could the government decide what to buy, and at what prices?[57]

The dangers of government buying look so profound that in October 2008, I recommended that if the government were to buy at all, it would be better for the government to invest through professional money managers, again piggy-backing on the choices they make to invest their own capital.[58] To help ensure that money managers had the right incentives, I also recommended dividing the government money up among a large number of private managers and making the investments and returns of these companies very public. These managers would then be competing with each other on a world stage to see how their investments performed. A more conventional incentive device would be to say that a manager gets no fees until the return on the assets passes some hurdle. Only after the taxpayers make money would the managers earn any fees.

The PPIP embodies a number of the same principles I advocated. Under the PPIP plan, the government has set up accounts with professional money managers in which each government equity dollar is invested side-by-side in the same securities with a dollar of investor capital. (This is in addition to the money loaned to the managers.)

Should another crisis arise, the government must be aware of the pitfalls of a large government buying program. The government cannot appear to the public as enriching the managers it entrusts with its money with fees that are too high. However, they must be given incentives to perform well. Otherwise, they might be tempted to spend taxpayer money buying portfolios sold by the failing companies of their cronies, in exchange for favors later on. Or they might pay less attention to the government investments than to the investments of their fee-paying clients. Or they might buy for the government with an eye toward benefiting their private clients by raising prices of assets the clients hold, or in some other way. These conflicts of interest become more acute to the extent that the number of managers is small and to the extent that they each have a huge amount of government money to wield. For example, a big enough buyer with government money could conceivably offer to rid a bank of toxic assets, at favorable prices, in exchange for favors like easier credit later on.

Another potential pitfall in government buying is the perverse incentives it might set up among sellers eager to get their securities purchased. For example, it may be that the banks were waiting for the government purchase not just of securities, but shaky whole loans too, and that hope may have contributed to their failure to modify whole loans in a rational manner.

Thus, even with all the advice I have offered about how the government should buy if it must, buying may still not be a wise policy, particularly not as a substitute for an adequate lending program, such as I described above.

6. Moral Hazard

It is often said that with every bailout comes a moral hazard that leads to a bigger problem the next time. The problem would be that bailing people out in this crisis would lead to higher leverage in the next cycle. There really is only one reliable antidote to that, and that is regulation of leverage.

[57] One suggestion that was made is by reverse auction. The government would divide the securities into different categories, and then buy from each category those securities that the current asset holders are willing to sell for the lowest price. But how would the government decide what the categories are and how much to spend on each? And how would it be protected from sellers' efforts to unload the worst securities in each category? If the purchases were to be made by an auction mechanism, I would have suggested a variation in which private bidders were allowed to enter the auction, not just private sellers. I would have recommended that the government commit to buying half the winners' purchases, at their winning prices. That way, the government could ride on the expertise of the private buyers. Still, even that solution could be gamed, particularly given that some private buyers might hold other positions—I am thinking of CDS here—that made it worthwhile for them to overbid in a manner that might not be easy to deter or discover.

[58] See Geanakoplos (2008).

One observation, which appeared in Geanakoplos and Kubler (2005), is that general systemwide interventions, like restoring sane leverage, in the crisis do not always create deleterious incentives in the long run. Surviving a crisis means tremendous profit opportunities in the good phase of the next cycle. If a systemic intervention gives prudent firms a chance to survive, rather than everyone going under, those firms will have an increased incentive to be prudent. Bailouts that rescue firms, no matter how imprudent they have been (in fact, precisely because they in particular were imprudent), are the source of moral hazard.

Some have suggested that writing down principal on mortgage loans will also cause moral hazard. They say it will encourage homeowners to behave badly, and the government to intervene in too many markets, and threaten the sanctity of contracts. I disagree, because the writing down of principal could be done as a function of the decline in some index of housing prices. The index is beyond the control of the homeowner, so it does not distort homeowner incentives. Moreover, it could be done first for homeowners who have not defaulted yet, and only later for homeowners who have defaulted under some special hardship. It could only be done, as I have said, if it promises to bring more money to the lenders. A good test of whether it is a good idea is whether it would be written into the contract in the first place if people had thought of the possibility of this much home price decline. I agree with Shiller (2008), who suggests that just these kinds of mortgages, with principal automatically reduced if some housing index falls enough, could and will likely become the standard mortgages of the future.

7. Managing the Ebullient Stage of the Leverage Cycle

After this crisis passes, we must prepare for the next leverage cycle. The first step is to constantly monitor leverage at the securities level, at the investor level, and at the CDS level.

Every newspaper prints the interest rates every day, but none of them mentions what margins are. The Federal Reserve needs to settle on a menu of different security classes, monitor their haircuts daily by talking to all the big lenders and borrowers, and then make averages public on a regular schedule, say every month or quarter.

The leverage of money managers could also be public. Moreover, legislation and regulations could contain strong and clear prohibitions against misleading the public or regulators on the degree of leverage.

I discussed at great length in Sections 3 and 4 how CDS contracts provide an opportunity to leverage, so these must be monitored as well. Putting them on an exchange would facilitate monitoring, as well as netting and ensuring enough collateral is posted. All too often CDS insurance buyers allowed the writers of insurance to get away without actually putting up the collateral. Repo lending too must be reorganized so that borrowers are protected in case the lenders go bankrupt and swallow up the borrower's collateral.

Transparency about actual leverage could bring a great deal of discipline to the market, and warn investors of impending trouble. In my earlier leverage charts, one can see the tremendous spikes in margins during the crisis stages of the last two cycles. One can also see a drift down in haircuts in the ebullient stage of the last cycle.

But transparency alone is not enough. Some investors will not curtail their leverage, no matter how much scrutiny by the public, and how far out of line with recent practice they become. Put bluntly, the market alone will not take care of outsized leverage. It is thus imperative that the Fed put outside limits on leverage. It will still be necessary to regulate leverage. The lesson of the leverage cycle is that there are many externalities (eight that I listed), and we should always expect cycles of too much leverage followed by too little leverage.

The most direct way to regulate leverage might be by empowering a "leverage supervisor" who could simply forbid loans at too high leverage in ebullient times, setting different leverage limits for different security classes. Banks would simply not be allowed to lend 97 percent of the value of the house, and repo lenders would not be allowed to reduce haircuts too far.

Many people have argued that setting margin limits is difficult because securities are so heterogeneous. But I believe this problem will eventually be solved once the haircut data history becomes more public. It was not obvious how to manage interest rates either. But little by little, the Fed has gotten better at it. The same will be true with leverage. The combination of security leverage data, investor leverage data, CDS leverage data, and asset price data could give the Fed tremendous information for managing future leverage cycles that it did not have, or chose to ignore, in this and in past leverage cycles. The critical thing is that with the data in hand, the Fed will be able to monitor dramatic changes in leverage and asset prices, and therefore will easily recognize when we are reaching either end of the cycle.

Another way of controlling leverage is to tax firms that borrow excessively, or that borrow excessively on their collateral, or that lend excessively on collateral. (The tax rate again would have to differ depending on the kind of

borrowing.) A very small tax might go a long way to discourage excessive leverage, and might also change the maturity structure, inducing longer term loans, if it were designed properly. Another advantage of the leverage tax is that revenues from it could be used to finance the lending facility the Fed would need to keep at the ready in anticipation of the downside of future leverage cycles.

Yet another way of controlling leverage is by mandating that lenders can only tighten their security margins very slowly. Knowing they cannot immediately adapt if conditions get more dangerous, lenders will be led to keep tighter margins in good, safe times.

Leverage constraints have been proposed at the investor level for selected financial firms. Congress is considering a hard cap on bank leverage of 15. There are six potential advantages, however, to limiting leverage at the securities level instead of at the investor level. The first is that many people can leverage; limiting leverage at banks or at a few other financial institutions might just induce leveraged purchases to move somewhere else. Second, the leverage of an investor is often a meaningless number, at least as an indicator of credit tightness, since just when things are getting bad, and margins on securities are tightening and the whole economy is being forced to deleverage, many firms will appear to be more leveraged because their equity will be disappearing. (It has become fashionable nowadays to say that leverage regulation should be countercyclical, by which people mean that investor leverage should be allowed to go up in bad times and down in good times. Enforcing a hard cap on investor leverage would paradoxically exacerbate the leverage cycle by forcing firms to sell at the bottom of the cycle, even if they had long-term loans that did not require rolling over.) Third, different securities include different amounts of "embedded leverage." Thus, it makes sense to mandate different leverage numbers for different securities. Setting an absolute leverage limit like 15, independent of the portfolio mix, might induce banks to shift their investments into securities with higher embedded leverage. Fourth, a focus on securities leverage would lead to derivatives such as CDS becoming part of the leverage numbers. As we saw, writing CDS insurance is like owning the underlying bond, so taking the ratio of the collateral required on the CDS to the cash price of the bond gives a good measure of the CDS leverage. Fifth, it is harder to hide securities leverage than investor leverage; for one thing, there is a counterparty to each security transaction reporting the same number that can be used by regulators as a check on reported numbers. Finally, a leverage supervisor managing securities leverage numbers might be less vulnerable to political pressure because his mandate would be more technical.

8. Conclusion

The leverage cycle brought us to the edge of a cliff. We have moved back from the precipice, but unless we understand the features of the leverage cycle and design our responses to address the specific problems that characterize the end stage of an outsized leverage cycle, we are left hoping for a miracle to restore our financial prosperity. Marking time and waiting for the miracle of things getting better appear to be part of the current government policy, at least as it relates to housing and foreclosures. That miracle, if it comes, will be nothing more than the start of another cycle, maybe one even worse than the one we have just experienced. My recommendations for solving the present crisis and managing the leverage cycle in its ebullient stage might prevent such an outcome.

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