

The Role of Liquidity in Financial Crises^{*}

Franklin Allen^{**}
University of Pennsylvania

and

Elena Carletti^{***}
University of Frankfurt
and
European University Institute

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^{**} Email: allenf@wharton.upenn.edu.

^{***} Email: carletti@ifk-cfs.de; and, from October 1, 2008, elena.carletti@eui.eu.

I. Introduction

The crisis that started in the summer of 2007 came as a surprise to many people. However, for others it was not a surprise. John Paulson, the hedge fund manager, correctly predicted the subprime debacle and earned \$3.7 billion in 2007 as a result. The vulnerabilities that the global financial system has displayed were hinted beforehand in the Bank of England and other Financial Stability Reports.¹ The Economist magazine had been predicting for some time that property prices in the US and a number of other countries were a bubble and were set to fall.²

Although the fall in US property prices that is the fundamental cause of the crisis was widely predicted, the effects that this had on financial institutions and markets were not. In particular, what has perhaps been most surprising is the role that liquidity has played in the current crisis. The purpose of this paper is to use insights from the academic literature on liquidity and crises to try to understand the role of liquidity during the last year. We focus on four possible effects of liquidity: on pricing, on interbank and collateralized markets, on fear of contagion, and on the real economy.

One of the most puzzling features of the crisis has been the pricing of AAA tranches of a wide range of securitized products. It appears that the market prices of many of these instruments are significantly below what plausible fundamentals would suggest they should be. This pricing risk has come as a great surprise to many. We argue that the sharp change in pricing regimes that started in August 2007 is consistent with what is known in the academic literature as “cash-in-the-market” pricing. Holding liquidity is costly because less liquid assets usually have higher returns. In order for providers of liquidity to markets to be compensated for this opportunity cost, they must on occasion be able to make a profit by buying up assets at prices below fundamentals. Once the link between prices and fundamentals is broken then arbitrage becomes risky and the usual forces that drive prices and

¹ See, for example, Bank of England (2006) and (2007).

² See, for example, Economist (2005) and (2006).

fundamentals together no longer work. This limit to arbitrage means that prices can deviate from fundamentals for protracted periods.

The second surprise has been the way in which the money markets have operated. The interbank markets for terms longer than a few days have experienced considerable pressures. In addition, the way that the collateralized markets operate has changed significantly. Haircuts have changed and low quality collateral has become more difficult to borrow against. The Federal Reserve and other central banks have introduced a wide range of measures to try to improve the smooth functioning of the money markets. The extent to which these events affect the functioning of the financial system and justifies central bank intervention depends on the possible explanations as to why the markets stopped operating smoothly. One of the main roles of interbank markets is to reallocate liquidity among banks that are subject to idiosyncratic shocks. If banks hoard liquidity and as a result they are able to cover idiosyncratic shocks from their own liquidity holdings, then their unwillingness to lend to other banks is not a problem. If, on the contrary, the liquidity hoarding prevents the reshuffling of liquidity to deficient, but solvent banks, then the badly functioning interbank market is a problem warranting central bank liquidity provision. Allowing banks to exchange mortgage backed securities for Treasuries is desirable if it improves collateralized lending in the repo market but is not if it simply leads to more window dressing by financial institutions. In this case the actions of the Federal Reserve are simply removing market discipline.

The third aspect of the crisis that we consider relates to contagion risk. The controversial use of public funds in the arranged merger of Bear Stearns with J. P. Morgan was justified by the possibility of contagion. If Bear Stearns had been allowed to fail, its extensive involvement as counterparty in many derivatives markets may have caused a string of defaults. There is a large literature on the likelihood of contagion between banks based on simulations. The conclusion of this literature is that contagion in banking is unlikely. However, some have argued that these simulations do not capture important elements of the

process. Whatever one's view of the likelihood of contagion in banking, it is important to conduct similar studies in the context of counterparty risk in derivatives markets.

Much of the academic literature on the role of liquidity in financial crises has focused on the effects on the real economy, mainly through the provision of liquidity to non-financial firms. We argue this has not been a significant factor to date in the current crisis. However, this may change going forward.

There is a growing literature on understanding the current crisis. Brunnermeier (2008) provides an excellent account of the sequence of events in the crisis focusing on a wide range of factors. Adrian and Shin (2008) argue that the dynamics of the crisis are driven by deleveraging. What sets our study apart from these papers is its primary focus on liquidity.

We start in Section II with a brief overview of the crisis focusing on the factors that are important for our subsequent discussion. Section III considers what liquidity in our context actually is and how liquidity created by banks, which is the focus of our study, can be measured. In Section IV we explain a theoretical framework for understanding liquidity provision. Section V applies this framework to gain insights into the current crisis. Finally, Section VI contains concluding remarks.

II. Liquidity and the Crisis

The crisis that started in the summer of 2007 is one of the most dramatic and important crises of recent decades. Its causes and unfolding have highlighted a number of new concerns and issues for policy makers, practitioners as well as academics interested in financial and monetary issues.

In the following we briefly outline the sequence of events. This provides a starting point for our discussion in subsequent sections. This description is mostly drawn from Federal Reserve Bank (2008a, 2008b) (see also Bank of England, 2008; European Central Bank, 2008; and International Monetary Fund, 2007 and 2008).

The crisis started in the first half of 2007 when the credit quality of subprime residential mortgages, in particular adjustable-rate ones, started to deteriorate. Mortgage companies specializing in subprime products experienced funding pressures and many failed. Although problems were initially confined to the subprime mortgage markets, further deterioration of credit quality and increases in the delinquency rates led to a spread of the crisis to other markets and products. By mid-2007 investors started to retreat from structured credit products and risky assets more generally, as rating agencies started downgrading many mortgage-backed securities. The securitization market for subprime mortgages simply broke down. Figure 1 shows that in July 2007 there was a tremendous jump in the co-movement of a range of AAA-rated tranches of structured financial instruments.

A general loss of confidence started to become pervasive. Signs of strain appeared in the leveraged syndicated loan market and in other leveraged lending markets in late June 2007, in the asset-backed commercial paper (ABCP) and in the term bank funding markets in August 2007. Spreads of collateralized loan obligations (CLOs) increased while the issuance of such debt reduced significantly, thus also reducing leveraged lending. Spreads on US ABCP widened significantly in mid August, while the volume of ABCP outstanding dropped significantly. This put substantial pressure on the structured investment vehicles (SIVs) that had heavily invested in structured financial products. Many had to activate the contingent liquidity support from their sponsor banks.

At the same time, problems arose in the term interbank funding markets in the US, Europe and the UK. Banks suddenly became much more unwilling to provide liquidity to other banks, especially for maturities longer than a few days. Reflecting that, Libor spreads rose significantly (Figure 2). The apparent reason for this liquidity hoarding was twofold. On the one hand, banks wanted to protect themselves against potential larger-than-anticipated liquidity needs deriving from the disruptions in the mortgage, syndicated loans and commercial paper markets. On the other hand, uncertainty about the counterparty risk

increased as banks could not precisely assess their counterparties' exposure to the subprime related securities and also to the other disrupted markets.

After a relief of the tensions in September and October following a 50 basis point reduction in the Federal Funds rate, tensions mounted again in November and December when end-of-the-year considerations became an additional element fueling the uncertainty deriving from the subprime market crisis. Spreads widened significantly again in all affected markets and a flight to quality led to a strong demand for safe assets and a sharp drop in Treasury bill yields.

Problems mounted again in March 2008 when, after the release of news of further losses and write-downs due to the use of mark-to-market accounting, the concerns started affecting more deeply the creditworthiness and the capital position of several institutions. Financial markets continued to be under great stress, particularly the markets for short-term uncollateralized and collateralized funding. Tensions culminated in mid-March 2008 when a sudden wholesale run on Bear Stearns impeded the investment bank obtaining funding on both unsecured and collateralized short term financing markets. Indicators of counterparty risk started being more significantly affected. For example, the cost of insurance against the default of large complex financial institutions (LCFIs), as measured by the credit default swap spreads, rose steadily in 2008 and reached an unprecedented peak around the time of the collapse of Bear Stearns (Figure 3).

Central banks around the world accompanied the unfolding of the crisis with numerous interventions. Some of these interventions concerned the usual reduction in policy rates (but the Fed also reduced the discount window rate in September 2007) as well as liquidity injections into the system. Other interventions concerned changes in the standard operational frameworks or the creation of more unusual, innovative forms of special liquidity schemes. Changes involved extensions in the maturity of central bank lending (in the US both with respect to the discount window loans in September 2007 and the open market operations

in March 2008), and widening of the collateral accepted. Special liquidity schemes introduced during the crisis include the Term Auction Facility in December 2007 through which credit is auctioned to depository institutions against Discount Window collateral, the Term Securities Lending Facility in March 2008 which allows primary dealers to swap less-liquid mortgage and other asset backed securities for Treasury securities, and, after the collapse of Bear Stearns, the Primary Dealer Credit Facility through which the discount window was extended to primary dealers. Similarly, a special liquidity scheme was introduced in the UK in April 2008 according to which institutions eligible for the standing facilities can swap collateral with Treasury Bills. Furthermore, both the Federal Reserve and the Bank of England were directly involved in managing and orchestrating the rescue, respectively, of Bear Stearns and Northern Rock; and the Federal Reserve recently established a temporary arrangement to provide emergency liquidity to Fannie Mae and Freddie Mac, should it become necessary. More recently, the US Treasury has been given the power, though on a temporary basis, to extend unlimited credit to (and invest in the equity of) the two Government Sponsored Enterprises.

Although the real effects of the crisis have so far been contained to some extent, initial signs of propagation seem to be emerging. Credit standards and terms on both commercial and industrial (C&I) loans and commercial real estate loans tightened and the yields on corporate bonds increased significantly over the first half of 2008 (see Federal Reserve Bank 2008, p. 12), indicating increasing pressures and risks for the nonfinancial corporate sector. Credit has remained available to the business sector so far, but household borrowing has slowed. Similar changes are occurring in the UK and Europe. The exchange rate of the dollar fluctuated during the crisis with a general trend towards depreciation against most currencies. Private payroll employment started falling substantially in February 2008, and inflation started also to be a source of concern. Economic growth remained slow in the first half of 2008, and the persistent weaknesses in the housing markets together with the tightened

conditions for credit to businesses and households also weakened the projections for the second half of the year.

III. Liquidity Provision by Banks

The term liquidity is used in many different ways. For our purposes liquidity is the ability to buy financial assets and real goods and services immediately. The most liquid asset is cash. Current and deposit accounts and assets such as Treasury Bills are also very liquid.

How should the liquidity of the financial system be measured? The focus of our study is on financial institutions and in particular on banks. Berger and Bouwman (2008a) have suggested a method for measuring liquidity created by the banking system and have applied it to the US. They start by classifying all bank assets and liabilities together with off-balance sheet items as liquid, semi-liquid and illiquid. They then assign weights to these three categories and calculate the amount of liquidity created by the banking system. They consider several possible measures. Their preferred measure includes off-balance sheet activities. According to this measure, in 2003 the US banking system created \$2.843 trillion of liquidity. This represented 39% of gross total assets and 4.56 times the overall level of bank capital. The amount of liquidity created by the banking system increased every year between 1993 and 2003 and during this period almost doubled.

In a subsequent paper Berger and Bouwman (2008b) use their measure of liquidity to investigate the relationship between liquidity and crises. Their sample period from 1984-2007 includes two banking crises, the credit crunch of the early 1990's and the current crisis. They focus on "abnormal" liquidity creation. This is defined to be the deviation from the time trend of liquidity creation adjusted for seasonal factors. They find that both banking crises in their sample have the feature that they were preceded by abnormal positive liquidity creation. This was particularly true for the current crisis. This reflects a build-up of capital and a loosening of lending standards. During the credit crunch of the early 1990's liquidity fell. For the

current crisis there is an indication of a fall after the start of the crisis but unfortunately, their data set only goes up to the end of 2007.

In order to understand the role of liquidity in the current financial crisis it is necessary to develop a theoretical framework for understanding liquidity creation by the banking system and how this relates to crises.

IV. A Theoretical Framework of Liquidity Provision

Liquidity has clearly played a very important role in the current crisis. Therefore it is important to have a theoretical framework for thinking about liquidity provision by the banking system and its contribution to the occurrence of crises. What follows is not meant to be a literature review, but rather a very brief description of the relevant concepts related to the crisis using a few papers.

Private Provision of Liquidity by the Financial System

Asset pricing theory in financial economics that provides the tools for asset valuation and risk management relies on the assumptions of fully rational agents and perfect and complete markets. In these models agents understand the risks involved in the investments they undertake and price them correctly. In a similar spirit, much of the theory that underlies central bank inflation-target policy in recent years relies on similar assumptions. In this frictionless world financial institutions have no role to play, and financial crises should never occur. However, they do occur, and as the current crisis shows, badly functioning money markets, financial institutions and their role as liquidity creators can be at center stage. Understanding recent events in terms of models without financial intermediaries is difficult, to say the least.

The first step in understanding the role of liquidity in financial crises is therefore to develop a model of liquidity provision in the context of financial institutions and markets.

We need to understand how a financial system can provide liquidity efficiently and what can go wrong. In this latter case, we also need to consider the potential role of central banks in improving the allocation of resources and maintaining financial stability.

The standard model of banking that allows consideration of the role of banks as liquidity providers was introduced by Bryant (1980) and Diamond and Dybvig (1983). There is a short asset that provides liquidity in the next period and a long asset that provides a higher return but at a later date. Consumers are initially unsure when they will require liquidity and they cannot directly insure this risk. In this view of the world the role of banks is to provide liquidity insurance to depositors.

The original banking models do not include financial markets. To understand the current crisis, it is essential to have a framework with both financial intermediaries and markets. Allen and Gale (2004a, 2007), among others, develop such an approach. They argue that in modern financial systems financial markets are essential for financial institutions. Consumers invest in financial intermediaries such as banks and mutual funds and these institutions then invest in financial markets. Information and transaction costs make it too costly for individual investors to trade directly in the full range of financial markets. Both financial intermediaries and markets play an important role in this environment. Financial intermediaries provide liquidity insurance to consumers against their individual liquidity shocks. Markets allow financial intermediaries and their depositors to share aggregate risks. This general equilibrium framework allows a normative analysis of liquidity provision by the financial system. It is like the Arrow-Debreu model of resource allocation but includes financial institutions. It provides a benchmark for the efficient provision of liquidity by intermediaries and markets.

Banks allow consumers to deposit funds that they can withdraw when they have liquidity needs. This liquidity provision allows banks to accumulate funds that they can use to lend to firms to fund long term investments. Banks must manage their liquidity so that they

can meet the liquidity needs of their depositors. There are two types of uncertainty concerning liquidity needs. The first is that each individual bank is faced with *idiosyncratic* liquidity risk. At any given date its customers may have more or less liquidity needs. The second type of uncertainty that banks face is *aggregate* liquidity risk. In some periods aggregate liquidity demand is high while in other periods it is low. Thus, aggregate risk exposes all banks to the same shock, by increasing or decreasing the demand for liquidity that all banks face at the same time. The ability of banks to hedge themselves against these liquidity risks crucially depend on the functioning, or, more precisely, the completeness of financial markets.

If financial markets are *complete*, the financial system provides liquidity efficiently in that it ensures that banks' liquidity shocks are hedged. One way to implement complete markets that allow every bank to hedge itself against idiosyncratic liquidity risk is as follows. Each bank issues a small amount of a security contingent on the idiosyncratic liquidity shock experienced by each *other* bank. With the funds generated by these securities, each bank buys all of the securities issued by the other banks that are contingent on its *own* idiosyncratic shock. Thus when a bank is hit by a high liquidity shock, it obtains the funds it needs to cover its liquidity requirements.³

The equilibrium prices of all these bank-specific securities together with securities that allow aggregate risk to be hedged lead to the efficient provision of liquidity by the financial system. The invisible hand of the market ensures that the pricing of the complete set of securities provides the correct incentives for the provision of liquidity by the banking system in every state.

The key point here is that the implementation of complete markets requires a large number of bank-specific securities, but in practice we do not see anything that resembles this kind of situation or provides an equivalent allocation. One possible reason is that the

³ See Allen, Carletti and Gale (2008) for a full description of how complete markets work.

infrastructure needed to support all the securities required for markets to be complete can be very costly in practice and thus not convenient. Although the current US financial system has many securities and many are specifically contingent on the particular experiences of specific firms such as credit default swaps, it is still a far cry from enabling the type of hedging transactions that correspond to the theoretical benchmark of complete markets.

If markets are *incomplete*, banks can trade only a limited number of assets and their ability to hedge liquidity risk changes dramatically. The incompleteness of markets leads to inefficient provision of liquidity by the financial system. This can generate *cash-in-the-market pricing*, where even the prices of safe assets can fall below their fundamental value, and lead to *financial fragility*, where even small shocks have large effects on asset prices. These effects provide an explanation of what can go wrong in imperfect financial markets.

Financial Fragility and Cash-in-the-Market Pricing

The problem with incomplete markets is that liquidity provision by the financial system is inefficient. The nature of risk management to ensure that the bank or intermediary has the correct amount of liquidity changes significantly from the case of complete markets. When markets are complete it is possible, as explained above, to use securities to ensure liquidity is received when it is needed. The price system ensures adequate liquidity is provided in every state and is priced properly state by state. In this case banks and other intermediaries buy liquidity in states where it is scarce by selling liquidity in states where it is plentiful for them, and the financial system allows risk sharing and insurance.

In contrast when markets are incomplete, liquidity provision is achieved by selling assets when liquidity is required. When liquidity is scarce asset prices are determined by the available liquidity or in other words by the cash in the market. It is necessary that a proportion of financial institutions hold extra liquidity that allows them to buy up assets when liquidity is scarce. These suppliers of liquidity are no longer compensated for the cost of

providing liquidity state by state. Instead the cost must be made up on average across all states and this is where the problem lies.

The providers of liquidity have the alternative of investing in a productive long asset. There is an opportunity cost to holding liquidity since this has a lower return than the productive long asset. In order for agents to be willing to supply liquidity they must be able to make a profit in some states. If nobody held liquidity, the price of the long asset would collapse to zero. This would provide an incentive for some agents to hold liquidity since they can acquire assets cheaply. But if the price increased too much, then nobody would hold liquidity as it would not make any profit. Thus, in equilibrium prices will be bid to the level where the profit in the states where banks face high liquidity demand is sufficient to compensate the providers of liquidity for all the other states where they do not make any profit and simply bear the opportunity cost of holding liquidity. In other words, prices are low in the states where banks need more liquidity. But this is exactly the wrong time from an efficiency point of view for there to be a transfer from the banks who need liquidity to the providers of liquidity. There is in effect negative insurance and suboptimal risk sharing. Asset price volatility is costly because depositors are risk averse and their consumption varies across banks with high and low idiosyncratic liquidity risk.⁴ This leaves scope for central bank intervention. By engaging in open market operations to fix the price of the long asset (or equivalently fix the short term interest rate), central banks can remove the inefficiency deriving from the asset price volatility and achieve the same allocation as with complete markets (Allen, Carletti and Gale, 2008).

To summarize, when markets are incomplete asset prices must be volatile to provide incentives for liquidity provision. This asset price volatility can lead to costly and inefficient crises. There is a market failure that provides the justification for central bank and other kinds

⁴ Allen and Carletti (2006, 2008a) analyze in detail how this pricing mechanism works.

of intervention to improve the allocation of resources. Liquidity provision in the complete markets allocation provides a benchmark for judging the effectiveness of such intervention.

Contagion

A second important concept when markets are incomplete is contagion. The linkages between banks that interbank markets provide imply that problems in one bank can spread to other banks and can potentially disrupt the whole financial system. Allen and Gale (2000) analyze a variant of the basic model of liquidity provision described above to consider how this process works and the inefficiencies involved.⁵ As with financial fragility, the problem is concerned with liquidity provision but in a somewhat different way. The possibility of contagion arises from the overlapping claims that different banks have on one another rather than from asset price volatility. When one bank suffers a shock and defaults as a consequence, the other banks suffer a loss because their claims on the troubled bank fall in value. If this spillover effect is strong enough, it can cause a crisis throughout the system. In extreme cases, the crisis passes from bank to bank, eventually having an impact on a much larger set of banks than the one in which the original shock occurred.

If there is a large degree of interconnectedness between banks in the sense that many hold the assets of others, there are many links through which a crisis can spread. On the other hand, the importance of each link will be smaller. This means that a shock can be more easily absorbed by the capital buffer of each institution. If there are a few links but each involves a larger amount of funds, crises are more likely to spread because each bank's capital buffer will be overwhelmed if another bank fails. Thus the case of some interconnectedness but not too much represents the most likely situation for contagion to occur.

Contagion is an extremely worrying phenomenon for policy makers. The costs of bankruptcy of financial institutions can be large. A whole string of bankruptcies among banks

⁵ For a survey of the literature on contagion see Allen and Babus (2008).

can cause tremendous damage to the financial system, and this in turn has the potential to have large spillovers to the real economy. If firms no longer have access to funding from banks or other financial institutions then they may have to cut investment and their level of output significantly.

Many factors affect the probability and the extent of contagion. One that seems to have played a role in the current crisis relates to the use of mark-to-market accounting. This accounting method has the benefit of reflecting the market value of the balance sheets of financial institutions and therefore of allowing regulators, investors and other users of accounting information to better assess the risk profile of financial institutions. This is true provided financial markets operate perfectly and prices reflect correctly the future earning power of assets. However, when markets do not work perfectly and prices do not always reflect the value of fundamentals as in the case where there is cash-in-the-market pricing, mark-to-market accounting exposes the value of the balance sheets of financial institutions to short-term and excessive fluctuations, and it can ultimately generate contagion. If there is cash-in-the-market pricing in one sector of the financial system, then other sectors can be affected by the change in the prices and may be forced to write down the value of their assets.⁶

Asymmetric Information

In our discussion of liquidity provision so far, asymmetric information has played a relatively small role. In particular, the assets that are traded are not characterized by asymmetric information. In the current crisis many people believe that asymmetric information has played an important role. Bolton, Santos and Scheinkman (2008) have provided an interesting theory of liquidity provision with asymmetric information.

⁶ See Allen and Carletti (2008a) for an analysis of mark to market accounting when there is cash-in-the-market pricing.

In their model there are three sets of agents. These are investors with a short horizon, intermediaries and investors with a long horizon. The basic source of inefficiency is asymmetric information about asset values between long-horizon investors and financial intermediaries. Long-horizon investors cannot distinguish between an asset sale that is due to a liquidity need and an asset sale to offload low quality securities. This asymmetric information leads to an adverse selection problem and consequently to a price discount. Bolton, Santos and Scheinkman assume that as time passes, the intermediaries learn more about the assets that they hold. This ensures that over time the adverse selection problem gets worse, and the price discount if an intermediary sells becomes greater.

The basic problem an intermediary faces if it is hit by a liquidity shock is whether to sell its assets now at a discount or to try and ride out the crisis. The danger of doing this is that the intermediary runs the risk of having to sell at a greater discount if the crisis lasts longer than expected. It is shown that two types of rational expectations equilibrium exist. In what they call the *immediate trading equilibrium*, intermediaries sell assets immediately to ensure they have enough liquidity. In the *delayed trading equilibrium* intermediaries try to ride out the crisis and only sell if they are forced to.

For some parameter values only the immediate trading equilibrium exists while for others both do. Surprisingly, the authors are able to show that the delayed trading equilibrium is Pareto superior when both exist. The reason is that short-horizon investors undervalue long assets while long-horizon investors undervalue cash. There is a gain from inducing short-horizon investors to hold more long assets and long-horizon investors more cash. This is what the delayed trading equilibrium does. The worse is the asymmetric information problem, the less is the gain as it impedes the operation of the market for the long assets.

Spillovers to the Real Economy

Much of the literature on liquidity provision has been concerned with the provision of liquidity to firms and resulting spillovers to the real economy. One of the important issues in crises is why problems in the financial system spill over into the real economy. The seminal contribution here is Holmstrom and Tirole (1998). In their model entrepreneurs operate firms. These entrepreneurs need to provide costly effort for the firm to be successful. In order to ensure they are willing to do this, they need to be provided with part of the equity of the firm. This limits the ability of the firm to raise funds by issuing securities to outside investors. If a firm is hit by a liquidity shock and needs more funds to continue, it may be unable to raise them in the market. If it cannot continue because of this, then it may go bankrupt and this can cause a significant loss in welfare. The occurrence of this event is more likely when credit markets are disrupted. In order to overcome this problem, the firm may need to hold liquid securities that it can sell in the event of a liquidity shock. If the private supply of such securities is insufficient, the government may be able to improve welfare by issuing government debt that can be held by firms. Now when firms are hit by a shock they will have sufficient liquidity to continue.

Another important contribution is Kiyotaki and Moore (1997). They show that small shocks can lead to large effects because of the role of collateral. A shock that lowers asset prices lowers the value of collateral. This means that less borrowing is possible, asset prices are further lowered and so on in a downward spiral. Disruptions in liquidity provision can be the shock that initially lowers asset prices and starts the problem.

V. Insights into the Current Crisis

In this section we focus on four of the crucial features of the crisis that we argue is related to liquidity provision. The first is the fall of the prices of AAA-rated tranches of securitized products below fundamental values due to liquidity factors. The second is the effect of the crisis on the interbank markets for term funding and on collateralized money

markets. The third is fear of contagion should a major institution fail. Finally, we consider the effects on the real economy.

1. Effects of liquidity on pricing

One of the most surprising aspects of the crisis has been the collapse in prices of even the AAA-rated tranches of mortgage-backed securities and other structured credit products. Some banks have had to write down the AAA-rated super senior tranches of mortgage-linked collateralized debt obligations by as much as 30 percent (Tett 2008) due to a fall in their market prices. According to the Bank of England (2008, pp. 18-21) if this change in price was due to deterioration in fundamentals, then it would be necessary to believe that the ultimate percentage loss rate of securitized subprime mortgages would be 38 percent. This would be justified, if, for example, 76% of households with subprime securitized mortgages would default and the loss given default rate was 50%. This seems, however, implausible given that none of the AAA-rated tranches have yet defaulted and, as the Bank of England also estimated, there should not be any future default in AAA-rated subprime mortgage-backed securities, even with a continued decline in US house prices.

It is not only AAA-rated tranches of subprime mortgage-backed instruments that have suffered but also commercial mortgage-backed securities and securitizations linked to corporate credit quality. As Figure 1 illustrates, at the start of the crisis the comovement of these instruments rose dramatically. The high correlation among different types of AAA-rated securities with quite different fundamentals shows that it is probably not fundamentals driving the falls in prices. Also, since the volumes traded in these instruments differ, it is not traditional liquidity factors that are driving these significant correlated changes in prices. All of this suggests that factors other than fundamentals are driving prices.

The framework developed in the previous section provides some insight into what could be determining prices. The movements observed are consistent with the cash-in-the

market pricing of securities explained above. In this framework it can be shown that aggregate shortages of liquidity can cause even risk free securities to trade at a significant discount to their fundamental. Moreover, the different types of security would all be affected so their prices would tend to move together.

One important feature of this pricing of AAA-rated tranches at such large discounts is their persistence. On the face of it, there would appear to be a significant arbitrage opportunity. By going short in similar maturity Treasuries and investing in these AAA-rated tranches a significant premium could apparently be earned. What prevents this? The answer is limits to arbitrage (Shleifer and Vishny 1997). In particular, once the link between prices and fundamentals is broken, the difference between them may widen in the wrong direction during the period of holding the position. It is well known that such limits to arbitrage can prevent even virtually identical securities from trading at the same price. The classic example is the shares of the Dutch company Royal Dutch Petroleum and the British company Shell Transport and Trading. Before July of 2005 when the two entities were formally merged into a single company, the shares of Royal Dutch Petroleum and Shell Transport and Trading were Siamese twins that shared in the profits of the oil major. Royal Dutch received 60% of the dividends and earnings of the joint company and Shell Transport and Trading received the remaining 40%. Standard asset pricing theory suggests they should have traded at a ratio of $60/40 = 1.5$. In fact they traded at very different price ratios than this (see, for example, Brealey, Myers and Allen 2008, p. 367).

It is interesting to note that although the prices of AAA-rated tranches of non-subprime mortgage backed securities such as commercial mortgage-backed and securitizations linked to corporate credit quality were significantly affected, the prices of conforming prime mortgage-backed securities issued by Fannie Mae and Freddie Mac were much less affected. This is not surprising given that here the arbitrage is virtually risk free

given the effective government guarantee provided to the securities of these government-sponsored enterprises.

Once the value of AAA-rated tranches of securitized products fell significantly, it no longer became possible to fund the SIVs holding them using short term finance. Thus the market for asset-backed commercial paper to finance such SIVs dried up since it was now clear the collateral was lower in value and also risky whereas before it was thought to be safe. To avoid loss of reputation, the banks that had set up these SIVs were forced to bring the underlying assets back on to their balance sheets. Their need for liquidity was thus dramatically increased.

In our view, one of the important features of the current crisis is therefore that cash-in-the-market pricing combined with limits to arbitrage has significantly affected the pricing of large volumes of fixed income securities for significant periods of time. Effectively this means that the creation by banks of uninsured off-balance sheet vehicles that borrow short and invest long has significantly increased risk in the financial system. Moreover, until significant experience has been gained concerning this type of risk of the cash-in-the-market pricing of such assets, the ability of financial institutions to manage risk exposures will be considerably impaired.

Another possible explanation of the pricing anomalies in the AAA-rated tranches of securitized securities is that they are due to asymmetric information as, for example, in Bolton, Santos and Scheinkman (2008). Strong adverse selection and moral hazard problems provide a potential explanation for the large discounts in prices for risky securities like those backed by subprime mortgages. However, the pricing of other AAA-rated securities as well as the correlation of price movements with other AAA-rated tranches shown in Figure 1 are more difficult to explain. Here the deterioration in the fundamentals of the underlying instruments was much less. Some other kind of factors must be at work for the asymmetric information to be consistent with what happened.

The Effects on Interbank Markets and Collateralized Markets

The second feature of the current crisis that has caused some surprise is the effect on the money markets. In particular, volumes in the interbank markets for maturities beyond a few days were significantly reduced. Less surprisingly, in the collateralized money markets, the haircuts on collateral increased significantly particularly for mortgage-backed securities as shown in Table 1. We consider each of these in turn.

One of the important issues with the interbank markets is the cause of the increase in spreads shown in Figure 2. These strains were particularly severe in December of 2007 and led the Fed to introduce special measures to provide liquidity, including the introduction of the Term Securities Lending facility to lend against Discount Window collateral.

Subsequently in March 2008, they lengthened the term they were willing to lend for in open market operations, introduced the Term Securities Lending Facilities to lend Treasuries against a broad range of collateral, and announced the Primary Dealer Credit Facility to lend bilaterally to primary dealers.

An important question is why these strains occurred and whether the actions of the Federal Reserve were warranted. As mentioned in Section II, two explanations are typically given as to why the interbank markets came under such strain. The first is that banks were hoarding liquidity in anticipation that they would have significant liquidity needs going forward. For example, they faced the possibility of having to bring many assets in SIVs and other off-balance sheet entities back on balance sheet as asset backed commercial paper markets dried up. Also, banks faced the prospect as the economy slowed down of corporations drawing down their lines of credit. All in all, liquidity had become scarce and

the prospect of uncertainty in aggregate demand for liquidity going forward meant banks wanted to hold onto as much as possible.⁷

The second explanation for the drying up of interbank markets is that increased uncertainty about the solvency of banks meant that they became unwilling to lend to each other. It is argued that uncertainty over which banks held subprime mortgages and the value of these, together with the uncertainty concerning other securitized assets, made it very difficult for banks to judge which banks they should lend to. If this is the explanation of the drying up of markets, then one would expect to see distrust of banks' prospects going forward to be reflected in the pricing of credit default swaps on banks. It can be seen from Figure 3 that the spread on credit default swaps on banks were elevated in December 2007 but by a relatively small amount. This was much less than the spreads that occurred in March 2008 at the time that Bear Stearns collapsed. The relatively low spreads in December 2007 suggest that banks reluctance to lend to each other probably plays a relatively small part in explaining why markets dried up. Liquidity hoarding is probably a more important factor.

If liquidity hoarding is the explanation, then the drying up of interbank markets may in fact not be a problem. It can be argued that the main role of interbank markets is to reallocate liquidity between banks to allow them to meet idiosyncratic liquidity shocks. If there is increased aggregate uncertainty about liquidity demand, banks will hold more liquidity and can then cover idiosyncratic demands without resorting to the interbank market. In this case the drying up of liquidity does not pose a threat to financial stability. In contrast, if the unwillingness of banks to provide liquidity prevents the efficient reallocation of liquidity to banks in need of liquidity, then financial stability can be affected and central bank intervention is warranted.

We next turn to the collateralized money markets. Much of the lending that occurs between financial institutions takes the form of short term collateralized repurchase

⁷ See Allen, Carletti and Gale (2008) for an analysis of the relationship between aggregate liquidity risk and liquidity hoarding.

agreements. In normal times a wide range of assets from Treasuries to mortgage-backed securities are used as collateral and they are regarded as close substitutes. Haircuts vary but by relatively small amounts. Table 1 shows that in crisis times this is no longer the case. This is partly because of the valuation issues discussed in the previous section that makes the securities more risky as collateral. In addition there is the issue that if there is a default, particularly of a major financial institution, there is likely to be a flight to quality. This will increase the value of Treasuries but reduce the value of lower quality collateral such as mortgage-backed securities. In extreme circumstances, the flight to quality may cause the value of the lower quality collateral to fall below the haircut the lender took. Thus Treasuries become a preferred form of collateral in times of crisis. In this view, the actions of the Federal Reserve and other central banks in making Treasuries more available by swapping them for lower quality collateral significantly helps the functioning of the repo markets in times of crisis.

One of the interesting characteristics of the strains in the interbank markets is that they were most severe in December of 2007 and around quarter's end in September 2007 and March 2008. This suggests that other considerations such as the desire of financial institutions to window dress may have also contributed to the strains. Musto (1997, 1999) presents persuasive evidence that financial institutions' desire to look good at year's end and the end of quarters leads to significant pricing effects in the money markets. Such desire may have been even more accentuated during the recent crisis. In this case the actions of the Federal Reserve in exchanging Treasuries for mortgage backed securities and lower quality collateral may actually hurt rather than help. Financial institutions can hold low quality securities for the period where no reporting is required. They then briefly buy Treasuries so that the balance sheet they report to shareholders or regulators is high quality. Temporarily increasing the supply of Treasuries makes this kind of deception easier. It helps remove market and regulator discipline.

An important issue is the extent to which the strains in the market and the increased appetite for Treasuries occurred because of a need for improved collateral or because of a desire to window dress. More research is needed to settle this issue and evaluate the desirability of the actions undertaken by the Federal Reserve and other central banks. One piece of information that would shed some light on the importance of these two factors is the extent to which low quality collateral was swapped for Treasuries and the extent to which these transactions were reversed afterwards.

3. Fear of Contagion

The justification that the Federal Reserve gave for arranging the takeover of Bear Stearns by J. P. Morgan was the fear of contagion [Minutes of the Federal Reserve, March 14, 2008]. Bear Stearns was the counterparty in a large number of derivative transactions. The fear was that if they had gone bankrupt there would have been contagion through the network of derivative contracts that they were part of and a large number of other financial institutions may have been adversely affected.

Contagion was discussed above in Section IV. Theories of contagion have mostly been developed in the context of banks and interbank markets. They show how a shock to one bank that causes bankruptcy can cascade through the financial system and cause a string of bankruptcies. If bankruptcy costs are high, then this string of failures can be very costly. The effect on asset prices may be large if failed institutions are forced to liquidate assets and there is cash-in-the market pricing. Moreover, there may be significant spillovers into the real economy if a significant number of financial institutions fail. Contagion potentially provides a strong justification for central banks to intervene and save institutions such as Bear Stearns. The key issue is how likely this kind of damaging contagion is in practice. This depends on the number and size of counterparties active in the market as well as on the size of the interrelations among them. The bigger and the more numerous are the counterparties and the

smaller the interrelations, the less likely it is that a default of one counterparty leads to contagion. The reason is that the buffers of capital of the surviving intermediaries are more likely to be large enough to absorb the default, especially if each of them has only small claims with the troubled intermediary. Given the characteristics of the markets where Bear Stearns operated, it is quite possible that this would have been the case and no contagion would have occurred.

Upper (2007) provides a survey of simulation exercises that look for evidence of contagious failures of financial institutions resulting from the mutual claims they have on one another. Most of these papers use balance sheet information to estimate bilateral credit relationships for different banking systems. The stability of the interbank market is tested by simulating the breakdown of a single bank. This methodology has been applied to the Belgian, German, Swiss, UK and US banking systems among others. These papers find that the banking systems demonstrate a high resilience, even to large shocks. Simulations of the worst case scenarios show that banks representing less than 5% of total balance sheet assets would be affected by contagion on the Belgian interbank market, while for the German system the failure of a single bank could lead to the breakdown of up to 15% of the banking sector in terms of assets. These results heavily depend on how the linkages between banks, represented by credit exposures in the interbank market, are estimated. For most countries, data is extracted from banks' balance sheets, which can provide information on the aggregate exposure of the reporting institution vis-à-vis all other banks. To estimate bank-to-bank exposures, it is generally assumed that banks spread their lending as evenly as possible. In effect, this assumption requires that banks are connected in a complete network. Hence the assumption might bias the results, in the light of the theoretical findings that better connected networks are more resilient to the propagation of shocks.

The main finding of this literature is that contagion is unlikely. However, there are a number of reasons for caution in accepting this result and concluding that policymakers

need not worry about contagion between banks. The first is that they do not model price effects of bankruptcy. Cifuentes, Ferrucci and Shin (2004) have argued that these price effects are the main transmission mechanism for contagion. As Upper (2007) points out, they also rely on the initial shock being confined to a single bank. If there is an initial shock that affects several banks simultaneously, then this can also lead to contagion being more likely.

In the case of Bear Stearns it is not clear from publicly available information how much contagion there would have been had it been allowed to fail. Press reports stress the large number of derivative contracts that Bear Stearns was a counterpart in. However, as argued above, this could mean that contagion was less likely because there would be more institutions with capital buffers to absorb the defaults. In any case, more simulations like those undertaken for banks are needed in the context of derivatives to assess the likelihood of contagion with this kind of default.

As a final point, one also has to keep in mind that even when there is a realistic risk of contagion that justifies central bank or government intervention, this also involves costs that should be traded-off against the costs deriving from contagion. These costs of intervention include the future moral hazard associated with increased risk taking by financial institutions going forward.

4. Effects on the Real Economy

As discussed in Section IV, much of the academic literature on liquidity has been concerned with firm's access to funds. If firms are limited in the amount they can raise because of factors such as moral hazard and adverse selection, they may be limited in the amount they can invest or may even fail if they suffer a liquidity shock. By holding liquid assets they can avoid this problem.

So far the indications outlined in Section II indicate that firms' financing has not been affected too much and in particular firms have not had to greatly restrict their investment

plans because of a lack of finance. However, credit standards and terms on corporate and real estate loans have tightened. In the first half of 2008 yields on corporate bonds also increased significantly. If the crisis continues to worsen, the effects on corporate finance discussed in the literature may begin to bite more seriously.

VI. Concluding Remarks

The fundamental cause of the current crisis has been the dramatic fall in property prices. Although this fall in property prices was widely anticipated, many aspects of the crisis that resulted were not and these have considerably exacerbated the effects of the crisis. We have focused on three of the most important. These are the following.

- The significant fall in prices of many AAA-rated tranches of securitized products including many unrelated to subprime mortgages.
- The drying up of interbank markets for maturities beyond a few days and the change in haircuts on collateralized lending.
- The fear of contagion.

We have argued that these phenomena are all intimately connected with the role of liquidity in financial crises. They have greatly exacerbated the effects of the crisis.

We suggest that the significant discounts on AAA-rated tranches of securitized products that are too large to be explained by the underlying fundamentals are the result of cash-in-the-market pricing. These price movements were unanticipated and have produced a whole set of problems for risk management going forward.

The drying up of liquidity in interbank markets is usually attributed to a mixture of liquidity hoarding by banks to counter the increased uncertainty over aggregate liquidity demand and fear of lending to other banks. At the end of 2007 the evidence seems to be that banks were to a large extent hoarding liquidity rather than refusing to lend to too counterparts

because credit default swaps on banks were only elevated somewhat. This is less of a problem than fear of lending as banks are not being refused credit.

In normal times high quality asset backed securities and Treasuries are close substitutes for collateral in the money markets. However, in crisis times they are not because the possibility of default will cause a flight to quality. This leads to a demand for Treasuries rather than asset backed securities. It is desirable for central banks to meet this demand to improve the efficiency of the money markets. However, in times of stress there is also a heightened demand for Treasuries for window dressing purposes at quarter and year end. Meeting this increased demand for Treasuries is not desirable as it removes an important market discipline. It is important that current facilities that allow asset backed securities to be swapped for Treasuries be evaluated in this light.

Theoretical analysis suggests that the process of contagion where default cascades through the financial system represents a significant danger. Contagion was the justification for preventing the bankruptcy of Bear Stearns as they were heavily involved as counterparties in the derivatives markets. However, little empirical work on the plausibility of contagion in the context of derivatives markets has been done. This is urgently needed.

In the remainder of this section, we consider some open issues related to the role of liquidity in financial crises that deserve attention. The first concerns mark-to-market accounting. One of the points we have emphasized is that cash-in-the-market pricing leads to prices that do not reflect fundamentals. If that occurs, mark-to-market accounting for financial institutions has the disadvantage that it can understate the value of banks and other intermediaries and makes them appear insolvent when in fact they are not. Historic cost accounting has the advantage that it does not do this. On the other hand, it leads to bankrupt institutions that deserve to be closed being able to continue and possibly gamble for resurrection. In Allen and Carletti (2008b) we suggest that in financial crisis situations where liquidity is scarce and prices are low as a result, market prices should be supplemented with

both model-based and historic cost valuations. The rest of the time and in particular when asset prices are low because expectations of future cash flows have fallen, mark-to-market accounting should instead be used.

The second issue is the “too big to save problem” of large banks in small countries. The Federal Reserve could easily prevent the threat of contagion posed by Bear Stearns. Even the threat of contagion posed by the failure of the largest banks in the US such as Citigroup and Bank of America could be avoided by central bank and government intervention even though this may require the outlay of very large amounts of government funds. However, some banks are so large relative to the countries in which they are based that this is not the case. One example is Fortis in Belgium. This has assets that are greater in size than the GDP of Belgium. If it were to fail it would be quite likely that a Belgian government (if one existed at the time) would be unwilling to intervene and assume fiscal responsibility because of the large size of the burden. In this case the key issue would be how the burden would be shared between countries of the European Union. Ecofin (2008, p. 5) specifies that “If public resources are involved, direct budgetary net costs are shared among affected Member States on the basis of equitable and balanced criteria,…” Unfortunately, this lack of specificity is likely to lead to substantial delays in dealing with the situation as each country vies to improve its fiscal position. During this time the prospect of contagion could effectively freeze many European and some global capital markets with enormous effects on the real economy. It is an urgent matter for the European Union to agree on specific ex ante burden sharing criteria for the costs of preventing large banking crises. The work along these lines that is currently under way needs to proceed rapidly.

Even more worrying is the fact that there exist banks that may fail in small countries that are not part of a larger grouping. The classic example here is UBS and Credit Suisse in Switzerland. These two banks both have assets significantly in excess of Swiss GDP. It may literally be infeasible for the Swiss government to raise the funds to prevent their failure. In

such cases the potential damage caused by the prospect of contagion if one of them were to fail is very large. It is again an urgent task to devise a system to prevent this kind of problem from occurring. The International Monetary Fund or the Bank for International Settlements are obvious institutions to be assigned to deal with such problems. The alternative is to wait for the catastrophe to occur. In that case consumers will subsequently be unwilling to invest in large banks in small countries. In the meantime, however, very large costs will have been imposed on the global economy.

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Table 1

Typical “Haircut” or Initial Margin
(in percent)

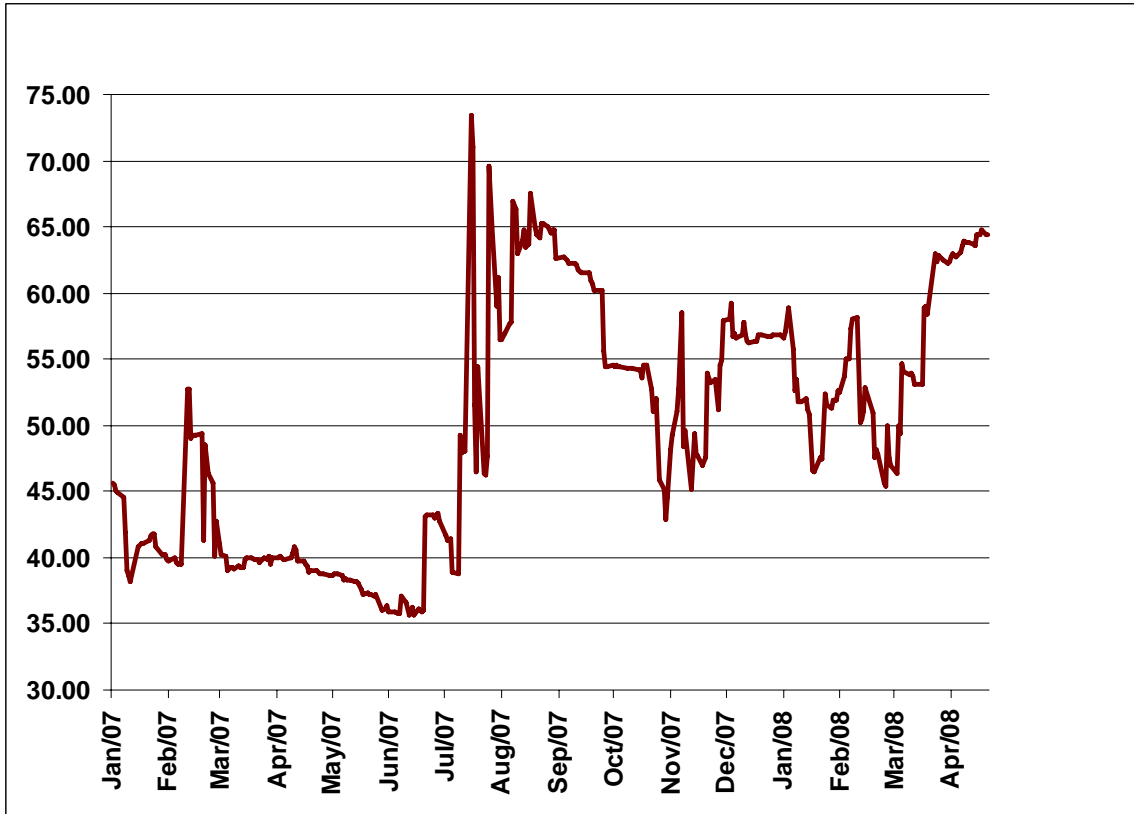
	January-May 2007	April 2008
U.S. treasuries	0.25	3
Investment-grade bonds	0-3	8-12
High-yield bonds	10-15	25-40
Equities	15	20
Investment grade CDS	1	5
Synthetic super senior	1	2
Senior leveraged loans	10-12	15-20
2nd lien leveraged loans	15-20	25-35
Mezzanine level loans	18-25	35+
ABS CDOs:		
AAA	2-4	15
AA	4-7	20
A	8-15	30-50
BBB	10-20	40-70
Equity	50	100
AAA CLO	4	10-20
AAA RMBS	2-4	10-20
Alt-a MBS	3-5	20-50

Sources: Citigroup; and IMF staff estimates – from International Monetary Fund (2008), Table 1.2, p. 23.

Note: ABS = Asset-backed security; CDO = collateralized debt obligation; CDS = credit default swap; CLO = collateralized loan obligation; RMBS = residential mortgage-backed security

Figure 1

Co-movement between AAA-rated US Structured Financial Instruments
(in percent)

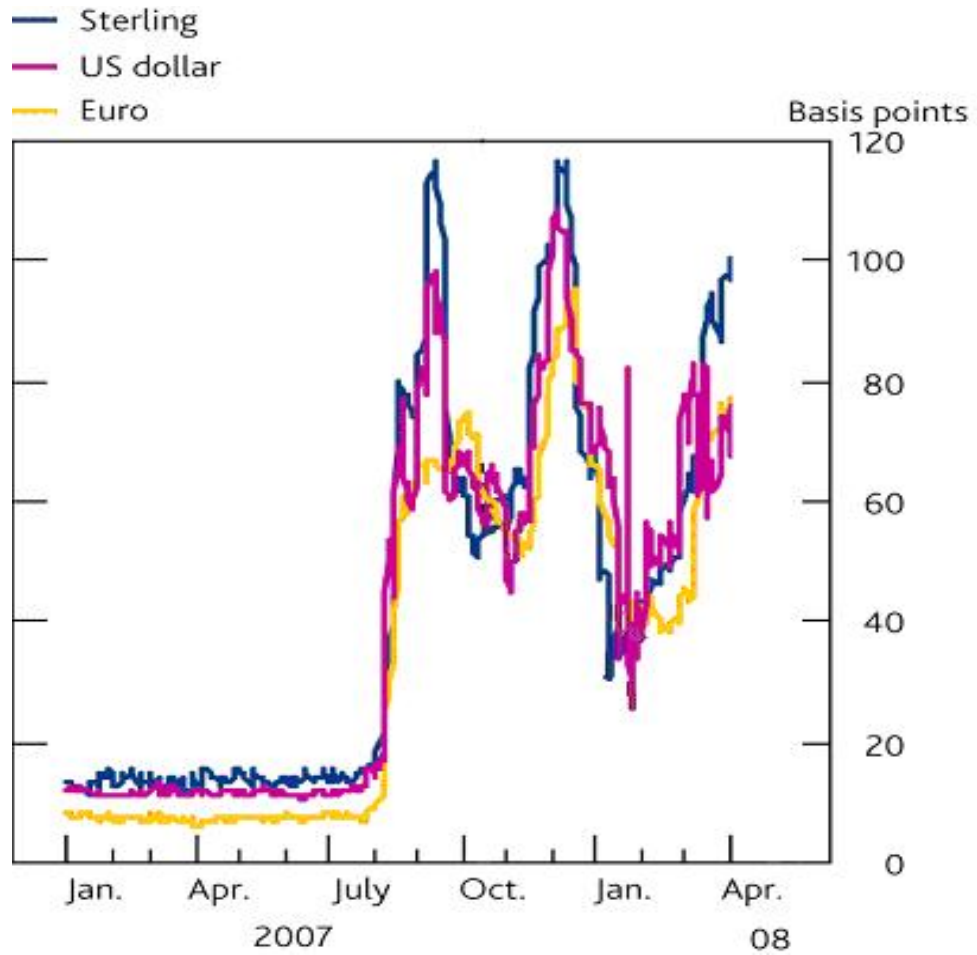


Source: Bank of England calculations using data from JP Morgan Chase and Co. – Bank of England Financial Stability Report (2008, p. 24, Chart 1.19).

Graph plots the proportion of the variation in exponentially weighted daily changes in credit default swap premia for the most senior tranche of the ABX HE 2006 H1, CMBX NA Series 1 and CDX NA explained by the first principal component over a three-month rolling window.

Figure 2

Three-month Interbank Rates Relative to Expected Policy Rates

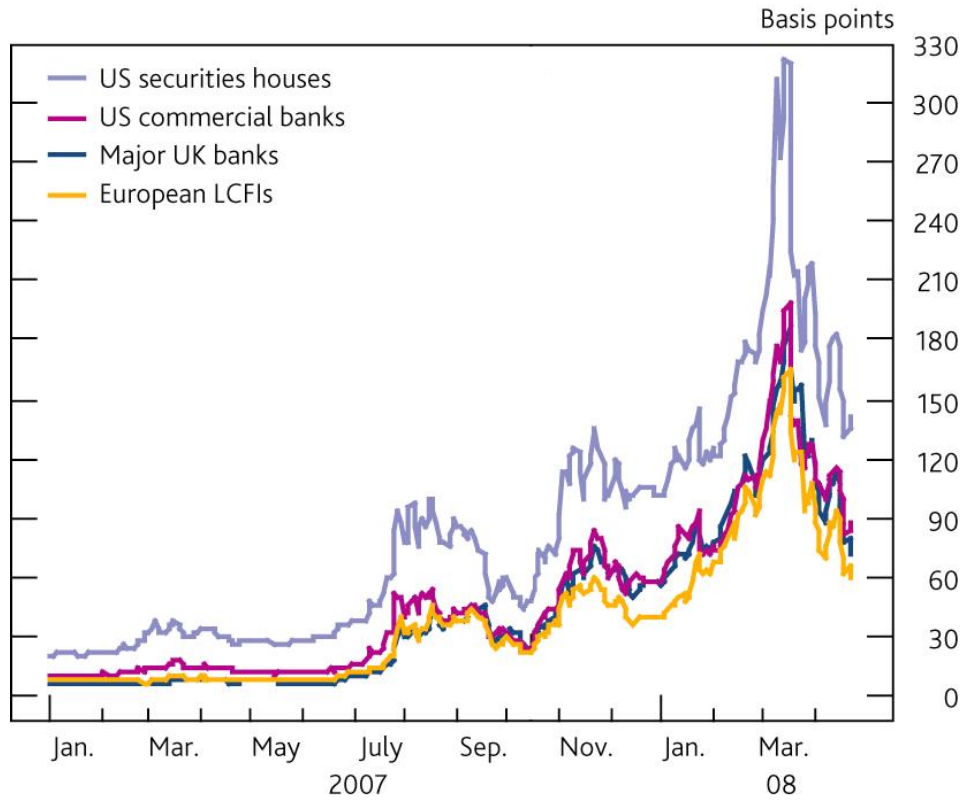


Sources: Bloomberg and Bank calculations – Bank of England (2008), Chart 10, p.11.

Spread of three-month Libor to to three-month overnight indexed swap (OIS) rates.

Figure 3

Major Large Complex Financial Institutions Credit Default Swap Premia



Sources: Markit Group Limited, Thomson Datastream, published accounts and Bank calculations – Bank of England (2008), p. 11, Chart 9.