Leveraged Losses: Lessons from the Mortgage Market Meltdown[†]

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Abstract

This report discusses the implications of the recent financial market turmoil for central banks. We start by characterizing the disruptions in the financial markets and compare these dislocations to previous periods of financial stress. We confirm the conventional view that the current problems in financial markets are concentrated in institutions that have exposure to mortgage securities. We use several methods to estimate the ultimate losses on these securities. Our best (very uncertain) guess is that the losses will total about $500 billion, with about half being borne by leveraged U.S. financial institutions. We then highlight the role of leverage and mark-to-market accounting in propagating this shock. This perspective implies an estimate of the eventual contraction in balance sheets of these institutions, which will include a substantial reduction in credit to businesses and households. We close by exploring the feedback from credit availability to the broader economy and provide new evidence that contractions in financial institutions' balance sheets cause a reduction in real GDP growth.

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1. Introduction

This report seeks to characterize and explain the credit market turmoil that began to grab headlines in August 2007. The associated fall-out has been an important driver of central bank policies since that time. Indeed, a number of Fed officials have linked these developments to monetary policy actions taken over the course of the past several months (see Bernanke (2007a,b and 2008), Evans (2007), Kroszner (2007), Mishkin (2007a,b), Poole (2007), and Rosengren (2007a,b)). This report offers a theory as to why credit market disruptions matter for the macro economy and some estimates of what the turmoil might imply about future growth.

Our analysis is broken down into four parts. We begin, in section 2, with a description of the key credit market events since August 2007. In doing so, we demonstrate that the credit crisis was not an across-the-board deterioration of all credit markets, but — at least in its early stages — an acute crisis that affected certain markets while leaving others virtually unscathed. At the epicenter of the turmoil are mortgage-related securities.

Having established the central role of mortgage-related debt in the crisis, in section 3, we try to assess the size of these credit losses and where those losses are concentrated. We find that the brunt of the losses are borne by the financial intermediary sector – both the traditional banks and broker dealers, as well as other entities involved in the securitization process.

In section 4, we offer an argument as to why the *incidence* of the losses (i.e., who bears the losses) is as important as how large those losses are. The characteristic feature of the financial intermediary sector is that it is composed of leveraged institutions whose capital is a small proportion of the total assets they hold. Credit losses deplete their capital cushion. We show that in past episodes, when faced with capital losses, intermediaries have scaled back their leverage and tried to rebuild their capital. Consequently, the overall decline in lending following the losses depends not only on the size of the initial shock, but also on the ability to raise new capital and on the extent to which the intermediaries reduce their target level of leverage. We provide a range of possible adjustments, but as a rule the overall lending reduction is many times larger than the capital losses. Our baseline estimates imply a $2.3 trillion contraction in intermediary balance sheets, of which roughly $1 trillion would represent a decline in lending to households, businesses and other non-levered entities.

This impending reduction in lending provides a possible link between the initial problems in the mortgage market and the rest of the economy. In section 5, we explore this channel. We first confirm past findings that have shown growth in total business credit to be strongly correlated with subsequent GDP growth. We then attempt to isolate the portion of this correlation that is due to fluctuations in the supply of credit. We find that, if anything, supply-induced credit contractions have stronger effects on GDP than non-supply-related changes. Our baseline estimates imply that the *independent effect* of the decline in credit due to the mortgage market losses will be to reduce GDP growth over four quarters by roughly 1.5 percentage points. While these estimates entail many

caveats, they still suggest that the feedback from the financial market turmoil to the real economy could be substantial.

We conclude with some provisional lessons for central banks from the events thus far.

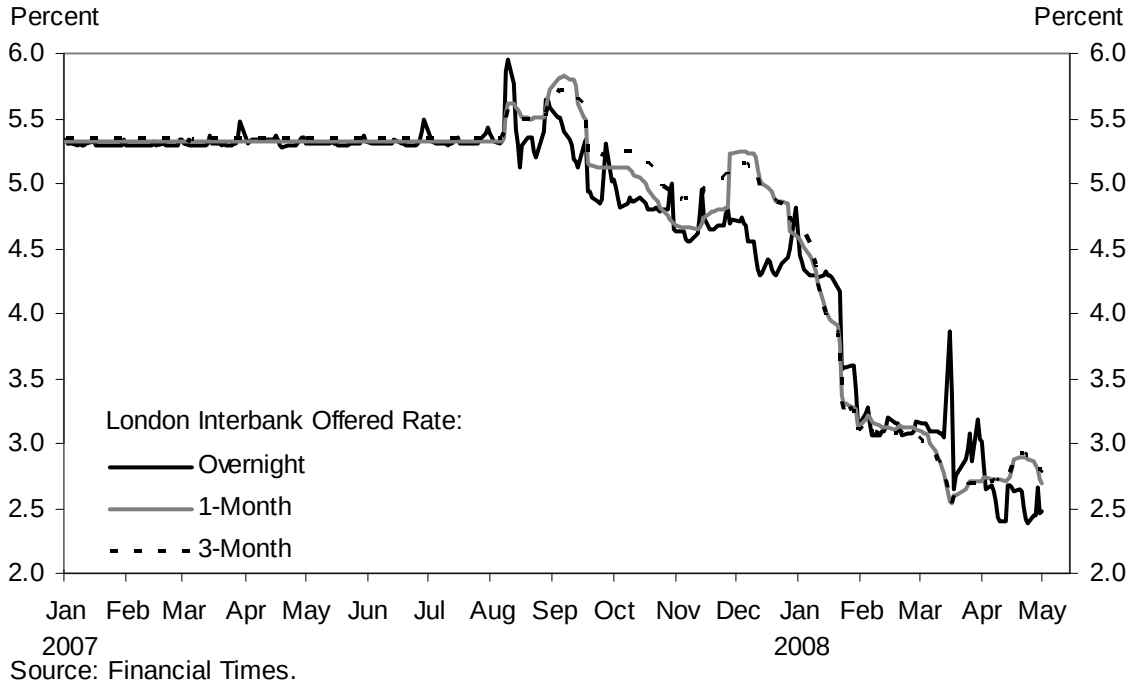
2. Credit Market Developments Since August 2007

We begin by describing the main events in the credit market since August 2007. In doing so, we note that some markets did not initially show signs of stress, which we will argue in the rest of the paper helps pinpoint the transmission channels operating during this crisis.

2.1 The markets that were disrupted

Signs of severe pressures in some credit markets became evident across the globe on August 9. In an interesting geographic twist, the proximate trigger seemed to be the announcement by a large European bank that it would close three investment funds because problems in the U.S. mortgage market had made it impossible to value the underlying assets.

Exhibit 2.1 LIBOR Rate



Source: Financial Times.

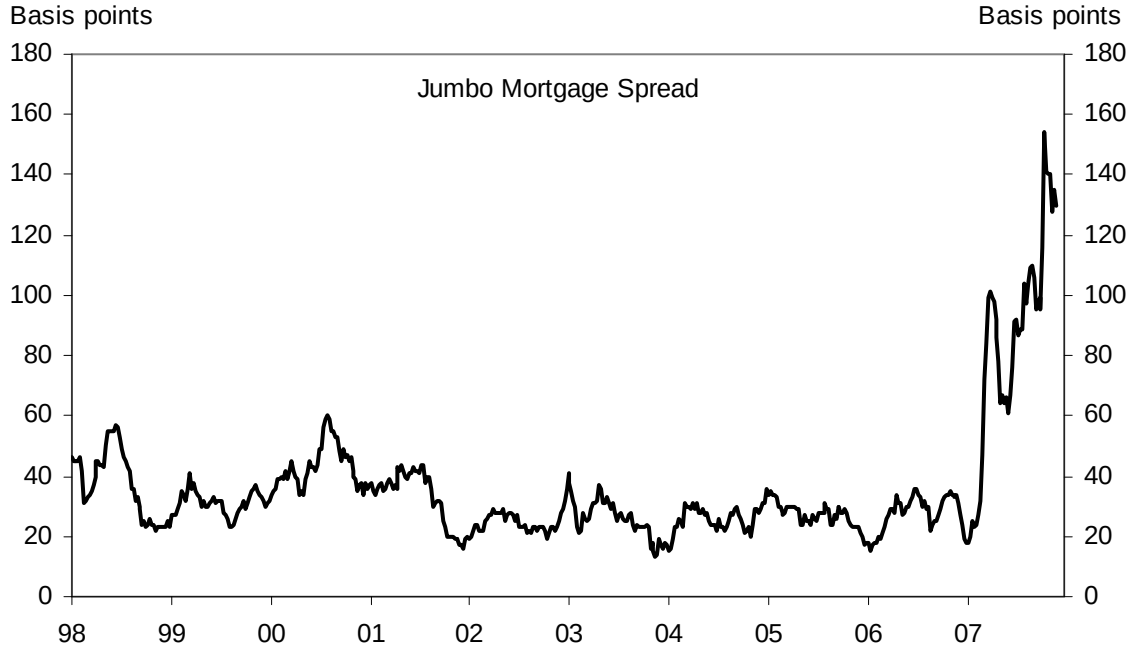
In response to emerging signs of stress, the overnight London Interbank Offer Rate (LIBOR) set more than 50 basis points (bp) higher than the previous day (see Exhibit 2.1). Term interbank funding rates – a measure that we will return to throughout this study – showed a similar move. LIBOR is a key benchmark rate for many types of consumer and business loans. Indeed, data compiled by the Federal Reserve Bank of New York (2007) indicate that 6-month LIBOR serves as the index rate for virtually all subprime mortgage

loans outstanding in the U.S. As we will demonstrate, the move in LIBOR on August 9 and the days immediately following was particularly noteworthy given evolving market expectations of future Fed rate cuts.

Meanwhile, the ECB – citing "tensions in the euro money market" – injected more than $130 billion into the system on August 9 in the type of emergency operation that had not been conducted since the aftermath of the September 2001 terrorist attacks. The Federal Reserve followed with unusually aggressive open market operations of its own a few hours later. Just days earlier, the Federal Open Market Committee (FOMC) had decided to leave monetary policy unchanged and had issued a statement that indicated the predominant policy concern was tilted toward inflation risk. But, on August 17, as signs of tightening credit conditions became increasingly apparent, the FOMC formally altered its assessment of the risks confronting the economy, and the Board of Governors slashed the discount rate by 50 bp.

The events that began to play out on August 9 triggered an intense examination of investor exposure to risk in the U.S. mortgage market. In the next section of this paper, we assess the magnitude of losses tied to subprime mortgages, but it's clear that one of the reasons that problems in this sector began to have far-reaching effects is that the loans under scrutiny were embedded in a wide variety of securities. Moreover, financial intermediaries had exposure to both the securities and the underlying loans. Thus, not only did the elevated risk now apparent in the subprime mortgage market lead to a sharp slowdown in origination of such loans, but there was significant spillover to other sectors such as jumbo mortgages, asset-backed commercial paper and collateralized debt obligations (CDO's).

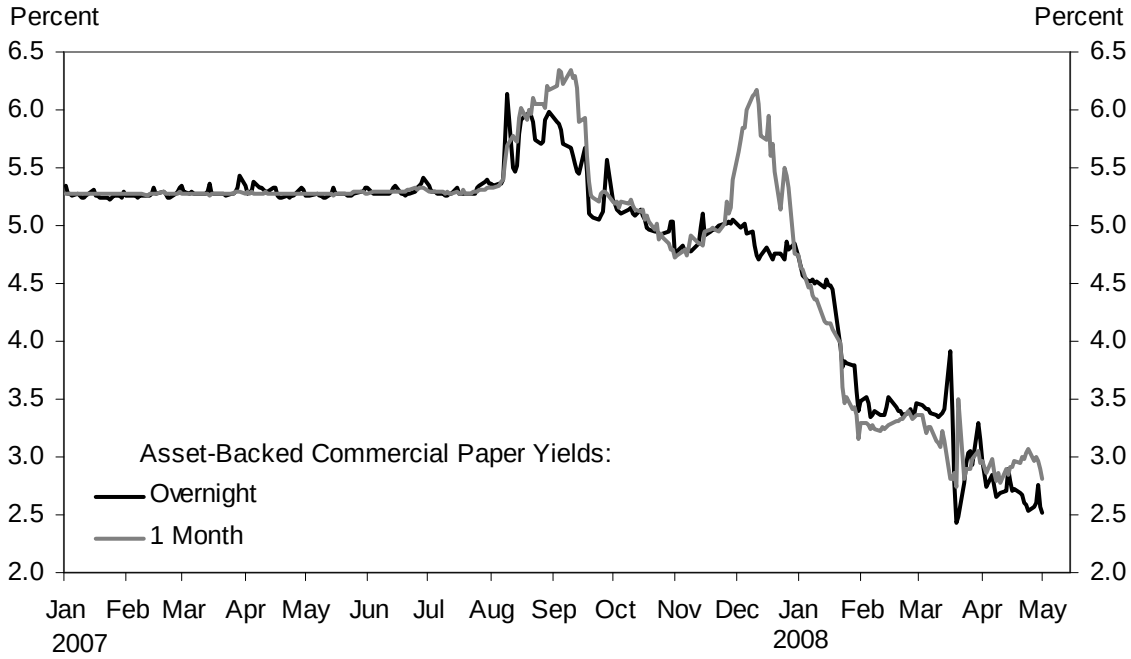
Exhibit 2.2 Jumbo Mortgage Spread



Source: BankRate.com.

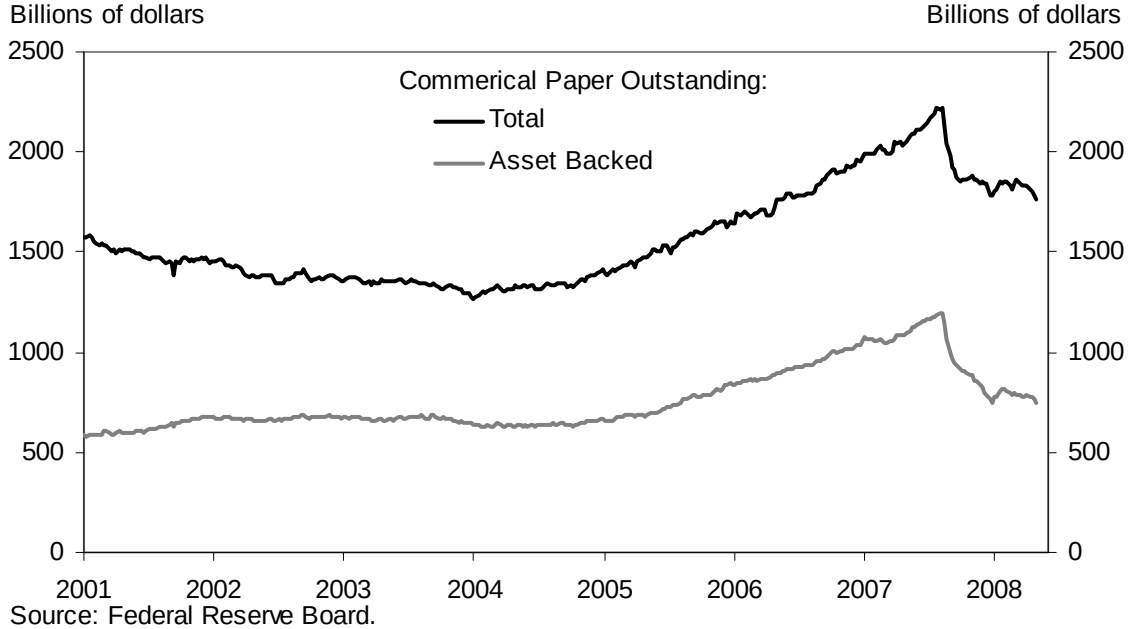
Jumbo mortgages account for 17% of the dollar value of all first-lien mortgage debt outstanding in the U.S., with nearly half of the loans being securitized. Roughly 50% of all jumbo mortgages are tied to homes located in the state of California (Office of Federal Housing Enterprise Oversight (2008)). Exhibit 2.2 shows a spike in the spread between jumbo and conforming mortgage rates that appeared first in August 2007. The typical spread is in the range of 20bp to 40bp, but since mid-August it has been much higher.

Exhibit 2.3 Asset-Backed Commercial Paper (ABCP) Yields



Source: Federal Reserve Board.

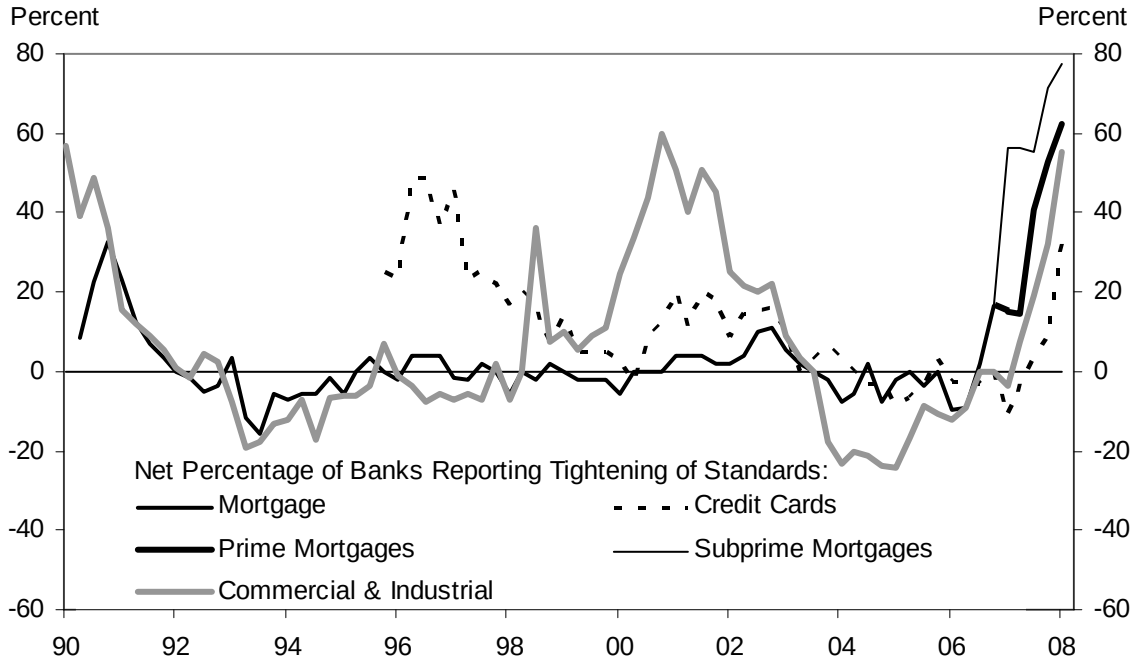
Exhibit 2.4 Commercial Paper Outstanding



Source: Federal Reserve Board.

Similarly, rates on asset-backed commercial paper spiked in mid-August (see Exhibit 2.3). Asset-backed Commercial Paper (ABCP) is a security issued by a bank or other financial entity with a maturity that is typically between 1 and 180 days. The notes are backed by the physical assets that are used as collateral for loans to households or businesses. The asset-backed component of the commercial paper (CP) market had grown at a phenomenal clip in recent years, and at the start of August it accounted for more than one-half of the $2.2 trillion of all CP outstanding (see Exhibit 2.4). According to a speech by William Dudley of the Federal Reserve Bank of New York, data from Moody's show that only about 25% of the collateral underlying ABCP as of mid-2007 consisted of residential mortgages (Dudley (2007)). However, while the direct exposure to subprime mortgage debt was relatively limited and the majority of ABCP programs were highly rated, investors appeared to have a great deal of difficulty evaluating the credit quality of the underlying assets. Issuers were confronted with an inability to roll maturing paper. Such a development would likely lead to either a forced liquidation of the underlying assets or the triggering of backstop credit agreements which would bring the assets onto bank balance sheets and intensify the strains that were already evident in term funding markets.

Exhibit 2.5 Senior Loan Officer Survey

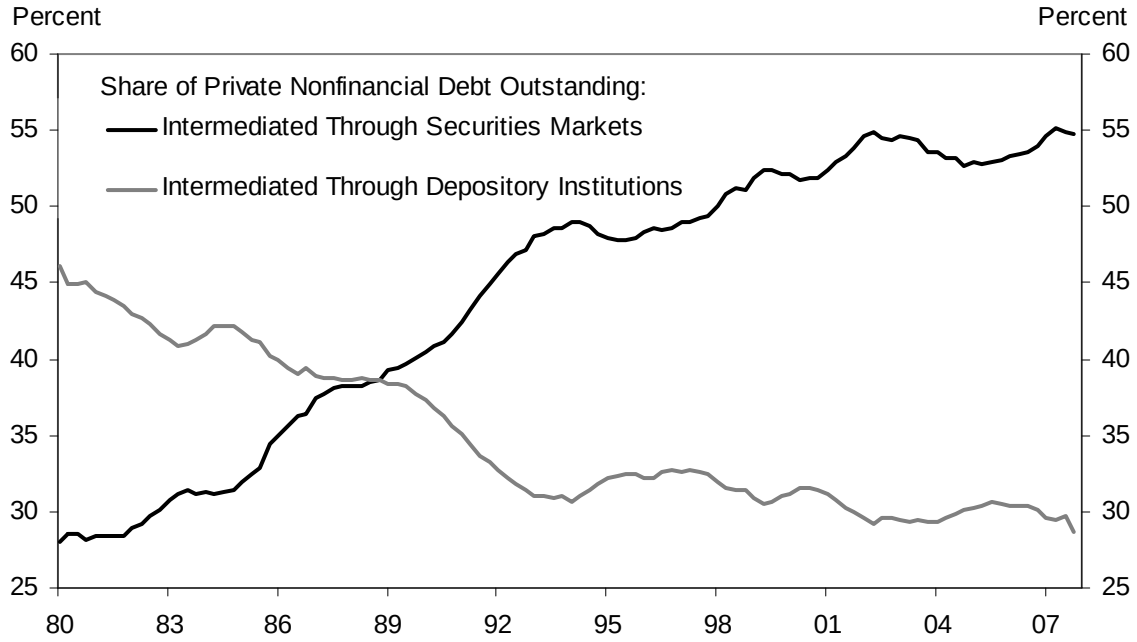


Source: Federal Reserve Board.

As funding rates rose and as problems in some securitized markets emerged, banks moved to tighten credit standards on a wide variety of loans – not just subprime mortgages. As seen in Exhibit 2.5, the Fed's Senior Loan Officer Surveys for October 2007, January 2008, and April 2008 showed a progressive tightening of standards for prime mortgages, commercial & industrial loans for businesses and credit cards. Thus, both of the main avenues of credit intermediation in the U.S. economy – the banking sector and the securities markets – were under some degree of stress. Exhibit 2.6 shows

the share of credit intermediation by depository institutions and by the securities markets. Examples of the former include mortgages, C&I loans, and credit card debt that remains on balance sheet. Examples of the latter include corporate bonds, commercial paper, and asset-backed securities. Note that the shares do not add to 100% because a small amount of intermediation occurs in a direct fashion – such as when a pension fund provides financing for a commercial mortgage. The securities market is certainly the dominant source of intermediation in the U.S. today. This is one of the ways in which the latest episode of credit tightening differs from those experienced in the 1980's and earlier. However, while the banking sector currently plays a much smaller role in the intermediation process than it did a couple of decades ago, it can still serve as an important allocator of credit and provider of liquidity in times of stress.[1]

Exhibit 2.6 Share of Intermediation through Banks and Securities Markets



Source: Morgan Stanley calculations based on Federal Reserve Flow of Funds Accounts.

2.2 Other non-affected markets

We now turn to another important characteristic of recent financial market developments – the delayed spillover effects. In the midst of the considerable pressures that we have described during the early stages of the credit tightening, some important asset classes seemed little affected. Indeed, even relatively high risk assets appeared to be immune to the initial signs of stress in the banking sector, mortgage market and commercial paper market. The table below shows monthly total returns for a variety of asset classes starting in July 2007. While most assets classes had negative returns in July, the cumulative

[1] See also Tucker (2007) for a helpful discussion of the linkages between the two channels that can become important during times of turbulence.

returns from July through October for all of the domestic indices, except the S&P financials, were positive. Only in November did clear signs of stress begin to appear.

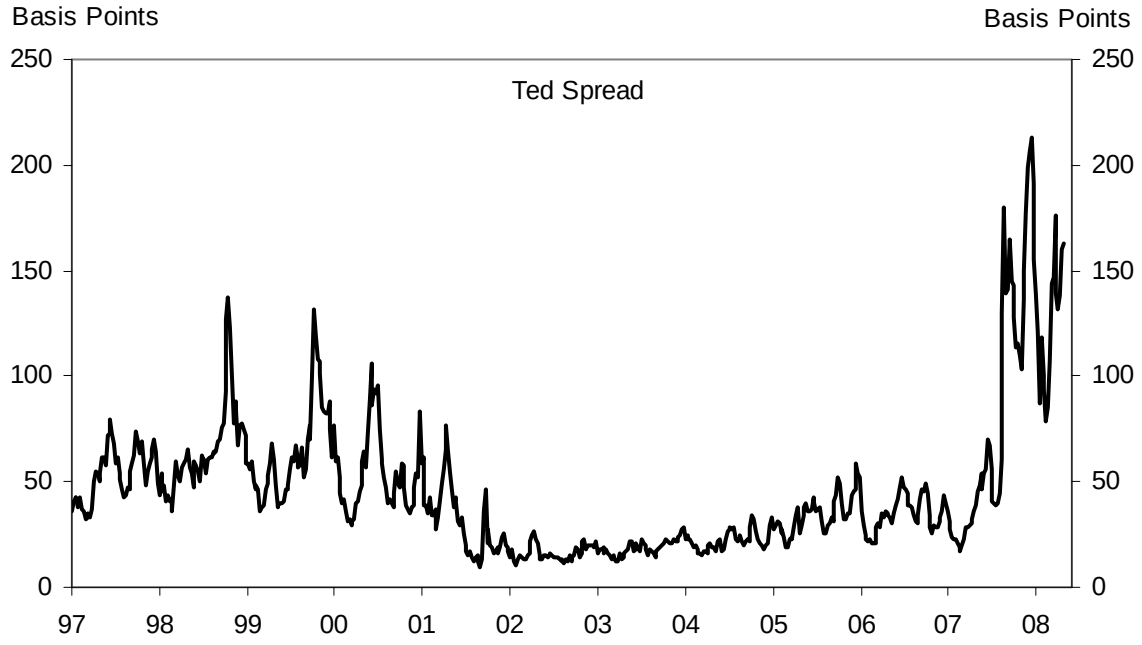
Exhibit 2.7 Monthly Total Returns on Various Asset Classes, July 2007 to January 2008

	Jul-07	Aug-07	Sep-07	Oct-07	Nov-07	Dec-07	Jan-08
S&P 500	-3.1%	1.5%	3.7%	1.6%	-4.2%	-0.7%	-6.0%
S&P Financials	-7.8%	1.5%	2.3%	-1.8%	-7.7%	-5.4%	-0.3%
Nasdaq	-2.2%	2.0%	4.0%	5.8%	-6.9%	-0.3%	-9.9%
Ryan Labs US Treasuries	1.8%	2.3%	-0.2%	2.8%	2.9%	-0.6%	3.7%
Merrill Lynch High Grade Corporate Bonds	0.6%	1.0%	0.5%	0.7%	1.4%	0.3%	2.2%
Merrill Lynch High Yield Bonds	-3.1%	1.1%	2.4%	0.6%	-2.0%	0.3%	-1.4%
EMBI+	-0.9%	1.6%	2.4%	2.6%	-0.5%	0.6%	0.7%
MSCI Europe (Local)	-3.5%	-0.5%	1.7%	2.9%	-3.8%	-0.5%	-11.4%
MSCI EAFE (Local)	-3.2%	-1.4%	2.3%	2.4%	-4.1%	-1.2%	-10.9%
MSCI EM (Local)	4.9%	-0.9%	8.4%	9.0%	-6.2%	0.6%	-12.4%

Sources: Factset. Haver. Bloomberg.

While U.S. equities, high yield bonds and emerging market debt were performing well through October, other measures of financial distress were already flashing clear warning signals. The TED spread – the difference between the 3-month Eurodollar deposit rate and the yield on 3-month Treasury bills – is a conventional gauge of credit risk since it measures the difference between an unsecured deposit rate and the rate on a government-backed obligation.[2] Exhibit 2.8 shows the TED spread plotted on a weekly basis. The widening in this measure that occurred during the final five months of 2007 far outstripped the moves associated with the LTCM crisis, Y2K and 9/11.

Exhibit 2.8 Treasury-Eurodollar (TED) Spread



Source: Financial Times. Federal Reserve Board.

[2] Note that the Eurodollar deposit rate is essentially the same as LIBOR.

The accompanying correlation matrices (Exhibit 2.9) show an alternative examination of the recent divergence between measures of credit risk and the performance of some important asset classes. The normal relationship – as measured by correlations during the 20-year period ending in June 2007 – is that a high TED spread is associated with a widening of corporate bond spreads, higher rates on jumbo mortgages (in relation to conventional mortgages), and a somewhat weaker stock market. In contrast, during the first few months of the credit market turbulence that began last summer, the correlation between the TED spread and corporate bond spreads was negative! There was a similarly counterintuitive change in sign for the correlation between the TED spread and equity returns – albeit at a much lower level of statistical significance. Meanwhile, we see an even more powerful positive link between the TED spread and jumbo mortgages. This divergence in correlations during the early stages of the credit stress highlights the concentrated nature of a problem that would appear to have far-reaching implications.

Exhibit 2.9 Correlations Between Measures of Credit Risk and Asset Returns

Correlations: January 1987 through June 2007

	TED	Baa-Aaa	S&P500	Jumbo
TED	1			
Baa - Aaa	0.22	1		
S&P500	-0.07	-0.07	1	
Jumbo	0.38	-0.19	0.05	1

Correlations: July 2007 through October 2007

	TED	Baa-Aaa	S&P500	Jumbo
TED	1			
Baa - Aaa	-0.46	1		
S&P500	0.05	-0.28	1	
Jumbo	0.93	-0.45	0.09	1

Series descriptions:
TED = Treasury/Eurodollar spread
Baa-Aaa = Spread between Baa and AAA seasoned bonds
S&P500 = 1 month return on S&P500
Jumbo = Spread between rates on Jumbo 30 year mortgages and conventional 30 year mortgages
Note: All data are weekly and start in August 1987, except Jumbo, which starts in June 1998.

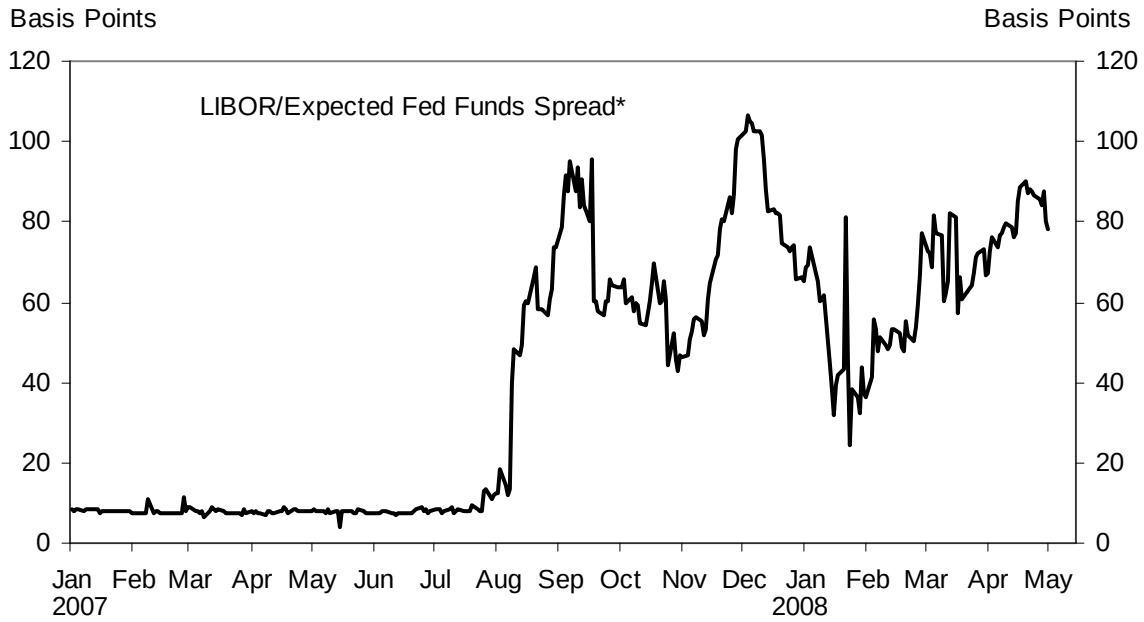
The TED spread can be influenced by "fight to quality" flows that move Treasury bill yields, as well as the funding pressures that drive LIBOR rates. For our purposes, a "purer" gauge of interbank funding pressures is the spread between LIBOR and the overnight indexed swap rate (or OIS). The OIS rate is a measure of the expected overnight federal funds target rate over a certain period. Meanwhile, LIBOR presumably incorporates the same policy expectation along with an assessment of credit and liquidity

risks. Exhibits 2.10 and 2.11 show the 3 month LIBOR-OIS spread on a daily basis for 2007 and early 2008 and on a monthly basis beginning in 1989.[3]

The high frequency LIBOR-OIS spread series (Exhibit 2.10) shows the relative calm that prevailed until August 9, 2007. This was followed by a fairly steady intensification of pressures through mid-September and then some relief in the wake of the 50 bp cut in the fed funds target at the September 18 FOMC meeting. There was renewed deterioration during early December as write-downs tied to mortgage-related losses mounted at banks and other financial services firms. However, the December 12th announcement of coordinated central bank action, including the Fed's introduction of the Term Auction Facility (or TAF), appeared to trigger some significant moderation in term funding pressures. This trend continued through year-end and into early 2008. In February, there was a renewed widening in the spread that seemed to be at least partly related to the ECB's February 1st announcement that it would discontinue the dollar liquidity operations that had commenced in December.

Compared to historical norms, the recent episode is also unusual. Exhibit 2.11 shows that, as with the TED spread, the current degree of stress is significantly greater than anything experienced in the past 18 years – surpassing the Y2K episode, the LTCM debacle in 1998 and the 1990-91 S&L crisis.

Exhibit 2.10 LIBOR-Overnight Indexed Swap (OIS) Rate (Daily)

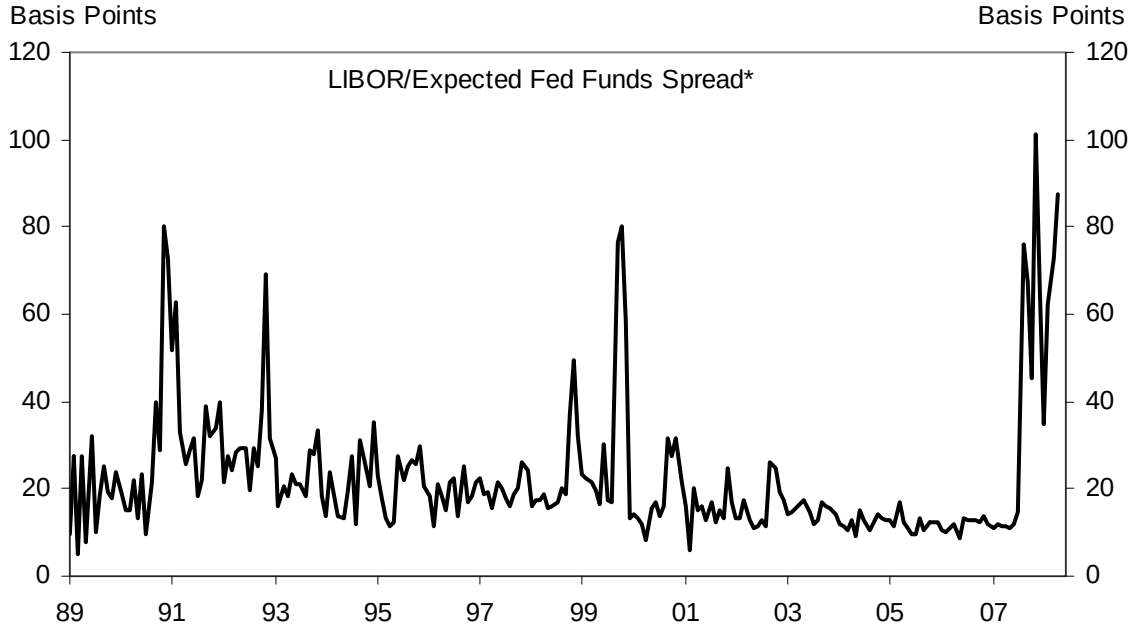


*Spread of 3-Month LIBOR over 3-Month OIS.

Source: Financial Times. Wall Street Journal.

[3] The monthly series is constructed by comparing the end-of-month LIBOR rate to the expected fed funds rate constructed using the next 3 months' fed funds futures contracts.

Exhibit 2.11 LIBOR-Overnight Indexed Swap (OIS) Rate (Monthly)



*Spread of 3-Month LIBOR over Average of Next Three Fed Funds Futures.
Source: Financial Times. Wall Street Journal.

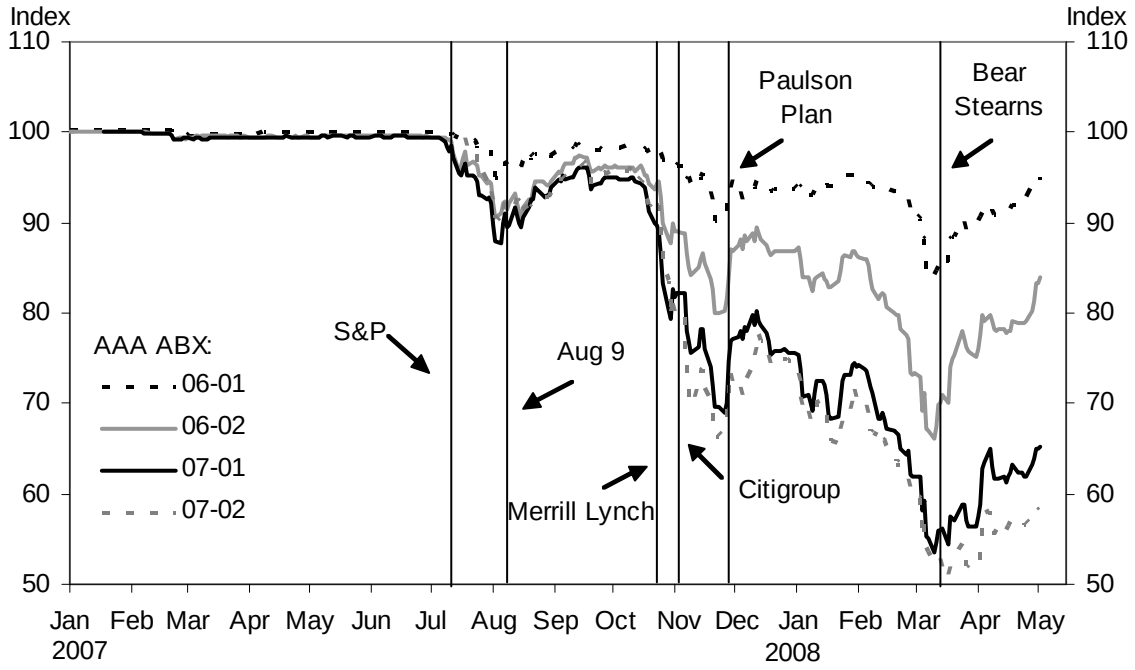
Not surprisingly, market estimates of subprime mortgage losses – as measured by the ABX index – have escalated since mid-2007. The ABX index represents a basket of credit default swaps linked to subprime mortgages. The indices are constructed by pooling mortgages with similar (initial) credit ratings. Exhibit 2.12 shows the indices for four vintages of AAA mortgages – the highest quality tranche of the underlying mortgages – which often include credit guarantees aimed at insulating these securities from credit risk. One of the hallmarks of the crisis has been the steep increase in the insurance costs associated with these so-called "super senior" tranches.

Many of the largest price swings in the ABX indices are associated with specific events that appeared to play a role in perceptions of the ultimate losses that will be realized. For example, a conference call with mortgage analysts at Standard and Poor's (a major rating agency) on July 10 seemed to drive the indexes lower. Following the liquidity injections of August 9, prices stabilized. Announcements in November 2007 of write-downs by major financial institutions, such as Citigroup and Merrill Lynch, appeared to help drive the index lower. Lastly, around Thanksgiving 2007, the unveiling of the so-called Paulson Plan by the Bush administration, seemed to temporarily stem the steady erosion in ABX pricing that had been evident in the weeks leading up to that point – even though the effort was viewed with skepticism by many analysts and investors.[4] But prices soon

[4] The Paulson Plan represents a broad-based attempt to modify the terms on certain subprime adjustable rate mortgages in a manner that might help avoid default. A few days after the plan was announced, a CNBC viewer poll found that more than 75% of respondents were opposed to its adoption.

began falling again with most reaching their lows on March 17 (the day of the announcement of the acquisition of Bear Stearns by JP Morgan).

Exhibit 2.12 ABX Indices (AAA Rated Vintages)



Source: Goldman Sachs.

Finally, as Boston Fed President Eric Rosengren has argued (Rosengren (2007a)), the recent problems evident in credit markets did not initially trigger a wholesale repricing of risk. Instead, the pressures evident in some key sectors (i.e., interbank funding, jumbo mortgages, and commercial paper) resulted from "liquidity problems" tied to the deterioration in the subprime mortgage market.[5] As we will examine in greater detail in sections 4 and 5, the resulting disruptions have gradually spilled over to other markets and this has contributed to a significant tightening of credit conditions across important sectors of the economy.

3. Estimating Mortgage Credit Losses

In estimating the credit losses for financial intermediaries, it is important to distinguish between the initial impact of losses tied to residential mortgages and the wider potential losses that would arise from knock-on effects. For example, a subdued pace of real activity that might arise due to problems in the residential mortgage market is likely to have an impact on the credit quality of commercial property and non-mortgage household debt (such as credit cards).

[5] In this sense, the failure of additional money to flow quickly to reduce these abnormal spreads is similar to the limits to arbitrage phenomena highlighted by Shleifer and Vishny (1997).

Our primary aim is to quantify the losses arising from mortgage assets alone – in particular those in the subprime sector – and to assess the impact of such losses on broader credit conditions in the U.S. economy. However, the progressive deterioration in credit quality outside residential mortgages is likely to add to the overall squeeze. In our baseline, we restrict our attention to residential mortgages, but we discuss other types of credit in the appendix. The appendix also addresses the impact of corporate income taxes on our estimates.

Conventional estimates of the likely mortgage credit losses over the next few years rose sharply during 2007. As recently as July 2007, Federal Reserve Chairman Bernanke noted that losses on subprime mortgages could total $50–$100 billion. Given typical estimates of the distribution of total losses between subprime and other mortgages, this number corresponds to overall losses of less than $150 billion. By the end of 2007, most mortgage credit modelers believed that total losses would be substantially higher. For example, by December 2007, Lehman Brothers (2007) was estimating that credit losses on the currently outstanding stock of mortgages would total $250 billion in their baseline scenario of a 15% peak-to-trough home price drop and $320 billion in a stress scenario with a 30% drop. Similarly, as of late November Goldman Sachs (2007) was estimating mortgage losses of $243 billion in their baseline scenario and $495 billion in a stress scenario.[6] In fact, during Congressional testimony on January 17, Chairman Bernanke admitted that losses could amount to "several multiples of [$100 billion] as we go forward and the delinquency and foreclosure rates rise." Subsequently, the International Monetary Fund (2008) estimated that losses on residential mortgages could total $565 billion.

In the remainder of this section we explain the procedure used by most private-sector analysts to arrive at their estimates. We then explore the robustness of these estimates to alternative assumptions about house price dynamics and arrive at our own baseline forecast. We close by discussing the likely distribution of the losses across different entities.

3.1 Deconstructing conventional loss estimates

The mechanics of these estimates is best explained by focusing on the $243 billion baseline estimate produced by the global bank analysts at Goldman Sachs. Their model simply extrapolates the performance – defaults, loss severities, and total loss rates – of each "vintage" (origination year) of subprime and other mortgage loans, based on its own history as well as the typical progression pattern through time. For example, suppose that the cumulative default rate on the 2006 subprime vintage is 3% at the end of 2007. Suppose further that the 2004 vintage showed a cumulative default rate of 1% after 1 year and 4% after 3 years, i.e., a fourfold increase over 2 additional years. Their procedure is to use the data on the 2004 vintage to extrapolate the cumulative default rate on the 2006

[6] The Goldman Sachs analysis is not directly linked to an assumed path for home prices, but the "stress" scenario stipulates a recession and peak historical default rates not only on subprime but also other mortgages.

vintage. In this scenario, the default rate on the 2006 vintage would be 12% by the year 2009.

In arriving at aggregate estimates, three basic observations prove to be important. First, default rates on virtually all types of mortgages originated prior to 2004 are relatively low, partly because most of these mortgages have already been refinanced. Second, default rates historically climb relatively quickly after the first two years, so that by years three or four one already has a good estimate of how a group of mortgages is likely to perform. One can think of a cohort of mortgages having an important common factor that drives defaults, and the magnitude of the factor is revealed relatively quickly. Third, the mix of mortgage originations shifted abruptly starting in 2004. Prior to that time there were relatively few subprime mortgages outstanding, whereas during 2004, 2005 and 2006 subprime and "Alt-A" originations surged.[7] Putting these facts together implies that most of the guesswork involved in arriving at aggregate loss estimates turns on how one assesses the performance of the lower-quality mortgages made during these three years (although by the end of 2007 most of the 2004 loans have been prepaid and either converted into prime mortgages or reissued as new subprime loans). Below we show some suggestive calculations that help to put bounds on the expected losses using this methodology.

3.2 Adjusting the conventional estimates for falling house prices

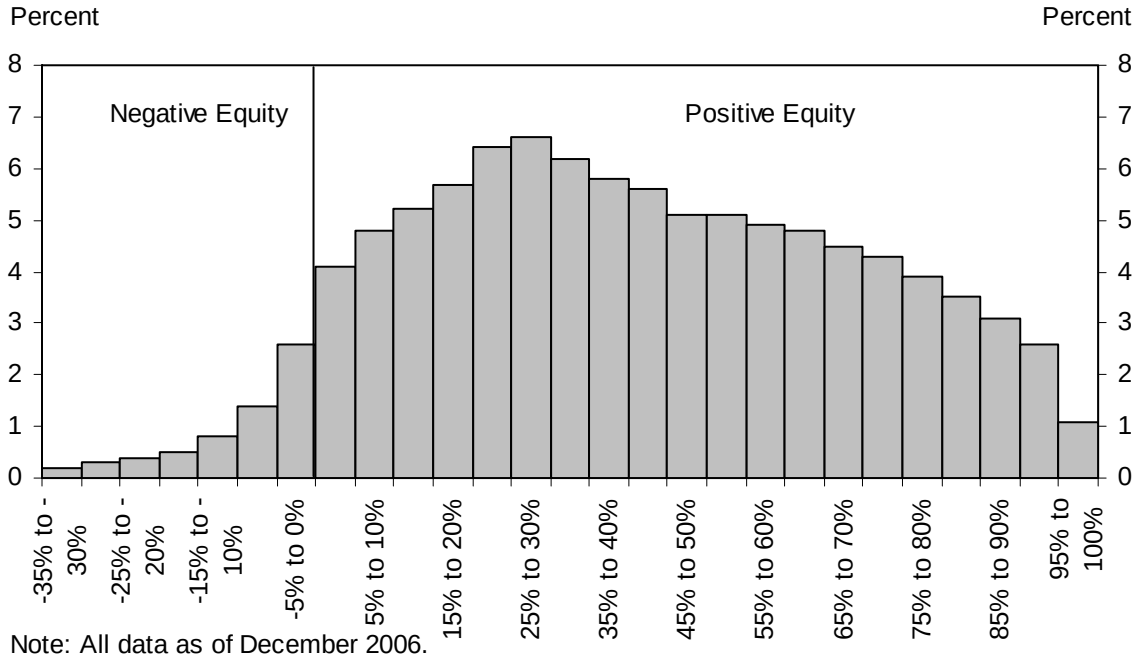
Although the modeling strategy described above seems quite logical, it does not account for the possibility of a structural break that might result from falling home prices. In particular, because the detailed mortgage performance data required to build these types of models are available only back to the mid-1990s, there are no observations on how defaults and losses on a particular vintage change through time when home prices start to fall. It is likely that simply extrapolating from the historical progression of defaults and losses will produce an overly optimistic picture. At the same time, it is difficult to know just how much to adjust the estimates given the lack of historical precedents. In the example given above, we suspect strongly that defaults on the 2006 vintage will not just grow in line with the progression observed in the past, but that the rise in defaults will exceed the historical norm, perhaps by a considerable margin.

The basic problem is that house price declines create large amounts of negative equity. Homeowners with negative equity cannot draw upon their capital gains buffer to cushion against adverse financial events such as job loss or mortgage reset by refinancing, and they therefore become much more likely to default. The importance of this problem is illustrated in Exhibit 3.1, which shows data compiled by First American CoreLogic on the distribution of home equity among U.S. mortgage holders at the end of 2006. About 7% of U.S. mortgage holders had negative equity at that point. Another 4% had equity of 0–5%, 5% each had equity of 5–10% and 10–15%, and 6% each had equity of 15–20% and 20–25%. Thus, the proportion of mortgage holders with negative equity would rise to 21% given a (uniform) home price decline of 15%, 27% given a drop of 20%, and 33%

[7] Alt-A loans are those whose credit quality is deemed to fall between that of prime and subprime – usually reflecting differences in items such as FICO score, loan-to-value ratio and loan documentation.

given a drop of 25%.[8] These are very large numbers. There are approximately 54 million households with mortgages in the United States, so 27% of all mortgage holders corresponds to about 14.6 million households. If negative-equity homeowners on average have mortgage debt of $250,000, this would imply that a 20% home price decline from late-2006 levels would put about $3.6 trillion of mortgage debt "under water."

Exhibit 3.1 Falling Prices Leave Homeowners with Negative Housing Equity



Note: All data as of December 2006.
Source: First American CoreLogic, Inc.

3.3 Alternative estimates for mortgage credit losses

What do these considerations imply for the likely amount of mortgage credit losses? We see three possible approaches that might be used to generate an estimate. First, we can start from the mortgage vintage models and judgmentally steepen the path for losses and severities relative to historical experience to reflect the expected home price declines. This suggests that total losses would be higher than the $243 billion baseline estimate in the Goldman Sachs analysis, which is simply based on "walking forward" recent credit quality trends without explicit consideration of the negative-equity dynamics. For example, if we raise the cumulative default assumptions for the 2004–07 subprime vintages by one-third to take account of the negative-equity dynamics and assume that non-subprime mortgage losses rise to half their historical peak rate, the Goldman Sachs analysis would imply total mortgage credit losses of around $400 billion. Of course, these are some extremely arbitrary assumptions, but they do illustrate that loss estimates are highly sensitive to a relaxation of the "business as usual" assumptions that are inherent in a simple vintage analysis.

[8] Fitch Ratings (2007) reports that 70% of the residential mortgage backed securities issued in 2006 were in areas that had negative housing price appreciation as of 2007Q2.

Second, we can look at the pricing of traded pools of different quality mortgage tranches to arrive at a market-based estimate of the losses. Exhibit 3.2 shows data from the trade publication *Inside Mortgage Finance* on the distribution of mortgages that were originated during this decade. As mentioned above, the share of subprime plus Alt-A mortgages jumped from around 10% of total originations during the period from 2001 to 2003, to nearly 25% in 2004, and then to better than 30% in the two succeeding years.

Exhibit 3.2 Mortgage Types by Year of Origination

Mortgage Originations by Product ($Bn)									
Year	FHA/VA	Conform-ing	Jumbo	Sub-prime	Alt-A	HEL	Total	ARMs	Refinan-ces
2001	175	1,265	445	160	55	115	2,215	355	1,298
2002	176	1,706	571	200	67	165	2,885	679	1,821
2003	220	2,460	650	310	85	220	3,945	1,034	2,839
2004	130	1,210	510	530	185	355	2,920	1,464	1,510
2005	90	1,090	570	625	380	365	3,120	1,490	1,572
2006	80	990	480	600	400	430	2,980	1,340	1,460
1Q06	19	236	103	140	105	102	705	297	348
2Q06	20	275	126	165	104	110	800	392	382
3Q06	22	241	128	160	91	113	755	332	368
4Q06	19	238	123	135	100	105	720	319	362
1Q07	19	273	100	93	98	97	680	240	388
2Q07	25	328	120	56	96	105	730	220	377
3Q07	26	286	83	28	54	93	570	166	263
4Q07	31	275	44	14	27	60	450	98	234

% of Originations by Product (except for Total Loans)									
Year	FHA/VA	Conform-ing	Jumbo	Sub-prime	Alt-A	HEL	ARMs	Refinan-ces	Total Loans ($Bn)
2001	7.9%	57.1%	20.1%	7.2%	2.5%	5.2%	16.0%	58.6%	2215
2002	6.1%	59.1%	19.8%	6.9%	2.3%	5.7%	23.5%	63.1%	2885
2003	5.6%	62.4%	16.5%	7.9%	2.2%	5.6%	26.2%	72.0%	3945
2004	4.5%	41.4%	17.5%	18.2%	6.3%	12.2%	50.1%	54.7%	2920
2005	2.9%	34.9%	18.3%	20.0%	12.2%	11.7%	47.8%	50.4%	3120
2006	2.7%	33.2%	16.1%	20.1%	13.4%	14.4%	45.0%	49.0%	2980
1Q06	2.7%	33.5%	14.6%	19.9%	14.9%	14.5%	42.1%	49.4%	705
2Q06	2.5%	34.4%	15.8%	20.6%	13.0%	13.8%	49.0%	47.8%	800
3Q06	2.9%	31.9%	17.0%	21.2%	12.1%	15.0%	44.0%	48.7%	755
4Q06	2.6%	33.1%	17.1%	18.8%	13.9%	14.6%	44.3%	50.3%	720
1Q07	2.8%	40.1%	14.7%	13.7%	14.4%	14.3%	35.3%	57.1%	680
2Q07	3.4%	44.9%	16.4%	7.7%	13.2%	14.4%	30.1%	51.6%	730
3Q07	4.6%	50.2%	14.6%	4.9%	9.5%	16.3%	29.1%	46.1%	570
4Q07	6.9%	61.0%	9.8%	3.0%	6.0%	13.3%	21.8%	52.0%	450

Source: Inside Mortgage Finance, Morgan Stanley.

To arrive at a set of losses we multiply the estimated distribution of different pools of mortgage-backed securities by the prices for the pools. While not all of these mortgages have been securitized, the implied losses can still be evaluated using the market prices for the securitized portion. We rely on analysis from Moody's that maps subprime originations into a distribution of mortgage-backed securities with various credit ratings (Moody's Investors Service (2007)). This distribution is shown in the Exhibit 3.3. The critical implication from the Moody's data is that roughly 80% of all subprime mortgages were converted into AAA pools. This means that any loss estimates will be particularly sensitive to the prices of the AAA tranches.

Exhibit 3.3 Estimates of Subprime Mortgage Originations by Rated Tranche ($Bn)

	All Subprime	AAA	AA	A	BBB	BB/Other
Year	100%	80.8%	9.6%	5.0%	3.5%	1.1%
2005	625	505	60	31	22	7
1Q06	140	113	13	7	5	2
2Q06	165	133	16	8	6	2
3Q06	160	129	15	8	6	2
4Q06	135	109	13	7	5	1
1Q07	95	77	9	5	3	1
2Q07	56	45	5	3	2	1
3Q07	28	23	3	1	1	0
4Q07	14	11	1	1	1	0
Total: 2005-2007	**1,418**	**1,145**	**135**	**71**	**51**	**16**

Source: Inside Mortgage Finance. Morgan Stanley.

The prices for the pools are taken from Markit.com's ABX indices.[9] The first set of ABX indices were launched in January 2006 and covered mortgages originated in 2005. Since the term to initial reset for adjustable rate mortgages in the subprime sector is generally two years, we assume that mortgages originated prior to 2005 were refinanced by 2007 and that those issued in 2005 and later were not able to be refinanced due to the tightening of credit standards. Notice the very sharp drop-off in subprime originations by the end of 2007. Thus, the cumulative issuance from 2005 through 2007 should approximate the universe of subprime mortgage debt that is currently outstanding. Indeed, note that subprime issuance during the 2005–07 timeframe totaled $1.4 trillion. Roughly 80% of this amount was adjustable rate. This means that the calculations are based on about $1 trillion of outstanding adjustable rate subprime debt – the same figure that Chairman Bernanke has often cited.

[9] The ABX has five separate indices based on the rating of the underlying security, from AAA to BB. Until recently, a new series was issued every six months to reflect the 20 largest deals. Therefore, each of the indices is constructed by averaging the quoted prices from roughly 20 trusts. The specific trusts included in each index are shown on the Markit.com web site.

To compare loss estimates, we report ABX prices as of three benchmark dates: August 9 (when the turmoil began), November 21 (just before the announcement of the so-called Paulson plan and the low point for 2007), and March 17, 2008 (the low point thus far for most of the ABX indices). The model shown in Exhibit 3.4 links the volume of originations during a certain time period to the price of the ABX index that most closely corresponds to that same timeframe. We find that the losses implied for subprime in the earlier periods range from $146 billion on August 9, 2007, to $511 billion on March 17, 2008. Meanwhile, as of May 19, 2008, the ABX market's implied loss had slipped back to $355 billion. Including losses for other types of mortgages, this would be consistent with well over $400 billion for total mortgage credit losses.[10]

Exhibit 3.4 Mortgage Credit Losses Implied by the ABX Contracts, various dates

August 9, 2007

	ABX Prices by Vintage						**MtM Loss ($Bn) based on ABX Pricing**					
	ABX Index	**AAA**	**AA**	**A**	**BBB**	**BB/ Other**	**Sub-prime**	**AAA**	**AA**	**A**	**BBB**	**BB/ Other**
Year	**100%**	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*	**100%**	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*
2005	ABX 06-1	96.42	94.50	85.95	60.94	49.06	38	18	3	4	9	4
1Q06	ABX 06-2	91.58	89.28	66.25	36.28	30.54	18	10	1	2	3	1
2Q06		91.58	89.28	66.25	36.28	30.54	21	11	2	3	4	1
3Q06	ABX 07-1	89.47	80.69	48.61	31.22	29.00	26	14	3	4	4	1
4Q06		89.47	80.69	48.61	31.22	29.00	22	11	3	3	3	1
1Q07	ABX 07-2	91.38	87.17	61.64	38.86	37.08	12	6	1	2	2	1
2Q07		91.38	87.17	61.64	38.86	37.08	7	4	1	1	1	0
3Q07		91.38	87.17	61.64	38.86	37.08	4	2	0	1	1	0
							146	**76**	**14**	**21**	**26**	**9**

[10] For instance, Citigroup (2008) provides a much more sophisticated analysis of loan level data and estimates that losses on "Alt-A" mortgages alone will be about 20% of losses on subprime mortgages. In an environment of broad home price declines, this estimate may prove to be conservative. Moreover, there will also be some losses on prime and jumbo mortgages. In sum, this probably implies that the ABX market is discounting total mortgage credit losses of well above $400 billion.

Exhibit 3.4 continued
November 21, 2007

	ABX Prices by Vintage						MtM Loss ($Bn) based on ABX Pricing					
	ABX Index	AAA	AA	A	BBB	BB/ Other	Sub-prime	AAA	AA	A	BBB	BB/ Other
Year	100%	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*	100%	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*
2005	ABX 06-1	90.09	78.24	50.41	25.46	22.75	100	50	13	15	16	5
1Q06	ABX 06-2	80.10	52.23	33.66	18.61	16.90	39	23	6	5	4	1
2Q06		80.10	52.23	33.66	18.61	16.90	46	27	8	5	5	2
3Q06	ABX 07-1	69.73	39.93	24.54	17.67	16.89	60	39	9	6	5	1
4Q06		69.73	39.93	24.54	17.67	16.89	51	33	8	5	4	1
1Q07	ABX 07-2	66.45	35.09	23.97	19.88	19.01	38	25	6	4	3	1
2Q07		66.45	35.09	23.97	19.88	19.01	23	15	3	2	2	0
3Q07		66.45	35.09	23.97	19.88	19.01	11	8	2	1	1	0
							369	**219**	**55**	**43**	**38**	**12**

March 17, 2008

	ABX Prices by Vintage						MtM Loss ($Bn) based on ABX Pricing					
	ABX Index	AAA	AA	A	BBB	BB/ Other	Sub-prime	AAA	AA	A	BBB	BB/ Other
Year	*100%*	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*	*100%*	*80.8%*	*9.6%*	*5.0%*	*3.5%*	*1.1%*
2005	ABX 06-1	85.81	64.34	33.22	16.19	14.81	138	72	21	21	18	6
1Q06	ABX 06-2	70.06	35.99	16.00	10.03	9.99	54	34	9	6	4	1
2Q06		70.06	35.99	16.00	10.03	9.99	64	40	10	7	5	2
3Q06	ABX 07-1	54.45	20.66	10.97	9.06	8.88	85	59	12	7	5	2
4Q06		54.45	20.66	10.97	9.06	8.88	72	50	10	6	4	1
1Q07	ABX 07-2	50.67	20.66	15.75	12.56	12.44	52	37	7	4	3	1
2Q07		50.67	20.66	15.75	12.56	12.44	31	22	4	2	2	1
3Q07		50.67	20.66	15.75	12.56	12.44	16	11	2	1	1	0
							511	**325**	**76**	**54**	**43**	**14**

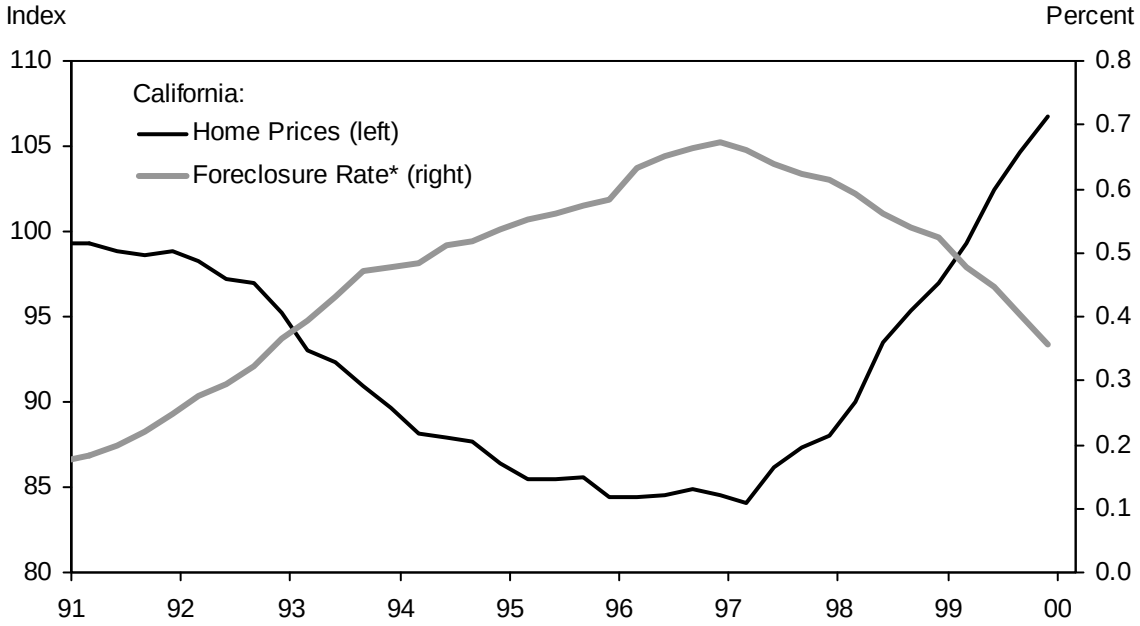
Source: Inside Mortgage Finance, Markit, and Morgan Stanley.

There are many caveats that come with these estimates. We know that trading is thin in the underlying loan pools. More importantly, the ABX prices probably include a risk premium that is necessary to induce investors to bear mortgage credit risk in the current mortgage credit crisis. It may therefore overstate the market's true expectation of future losses, although the size of this overstatement is difficult to gauge. Nonetheless, we find it interesting that the range of losses from this exercise is not too different from the one obtained using calculations from method one above.

Our third method for estimating the losses draws on the past foreclosure experience of individual regions that have seen significant nominal home price declines. While nationwide nominal home price declines have been rare in the United States — at least in the four decades for which we have reasonably reliable data — the same is not true for states such as California, Massachusetts, and Texas in different periods during the 1980s

and 1990s. The experiences of these three states are shown in Exhibit 3.5. In all cases, nominal house prices fell 10%–15%, and the foreclosure rate — the (not annualized) percentage of all outstanding mortgages entering foreclosure per quarter — continued to rise until home prices had bottomed. Subsequently, foreclosures did not normalize until after home prices had regained their previous peak, which took another 3-6 years.

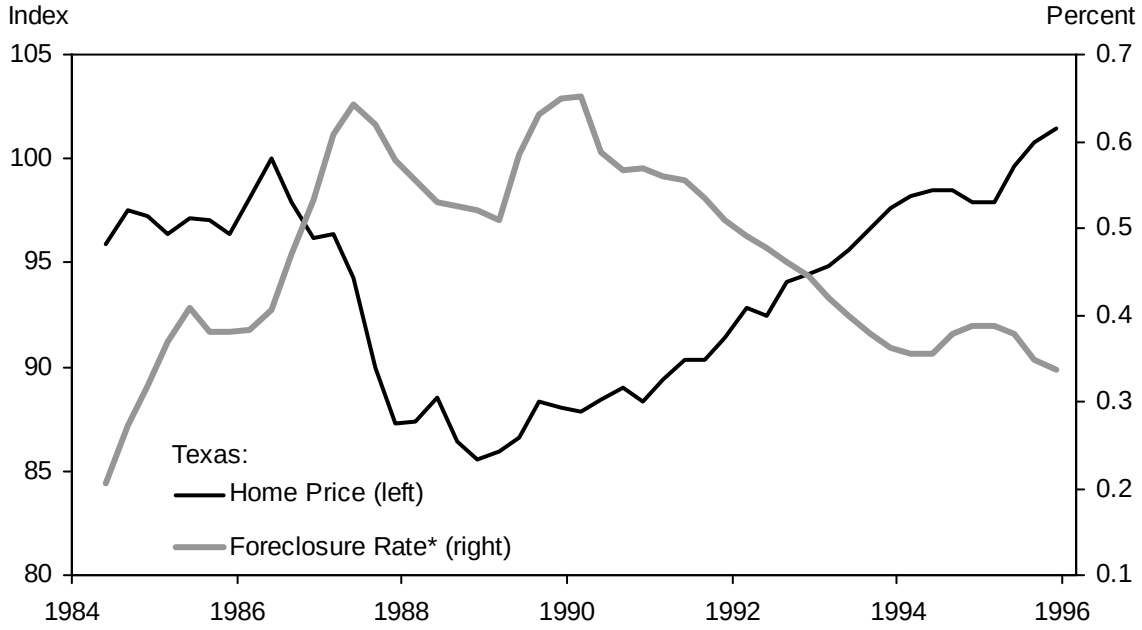
Exhibit 3.5 A Look at Three Regional Housing Busts



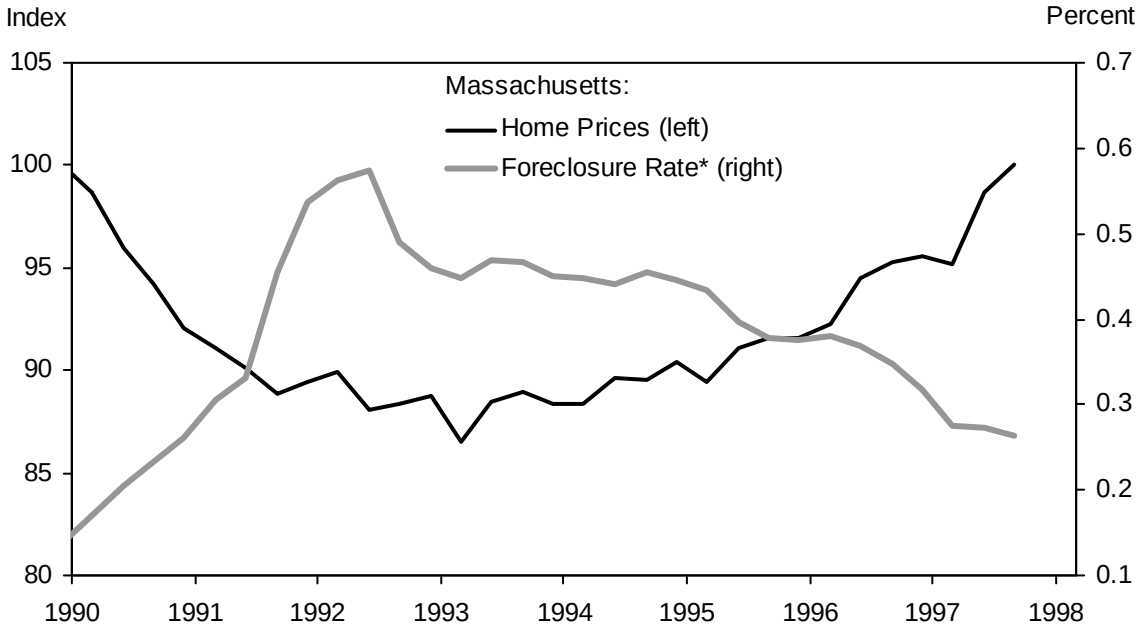
* 4-quarter moving average.

Source: Mortgage Bankers Association. OFHEO.

Exhibit 3.5 continued



*4-quarter moving average.
Source: Mortgage Bankers Association. OFHEO.



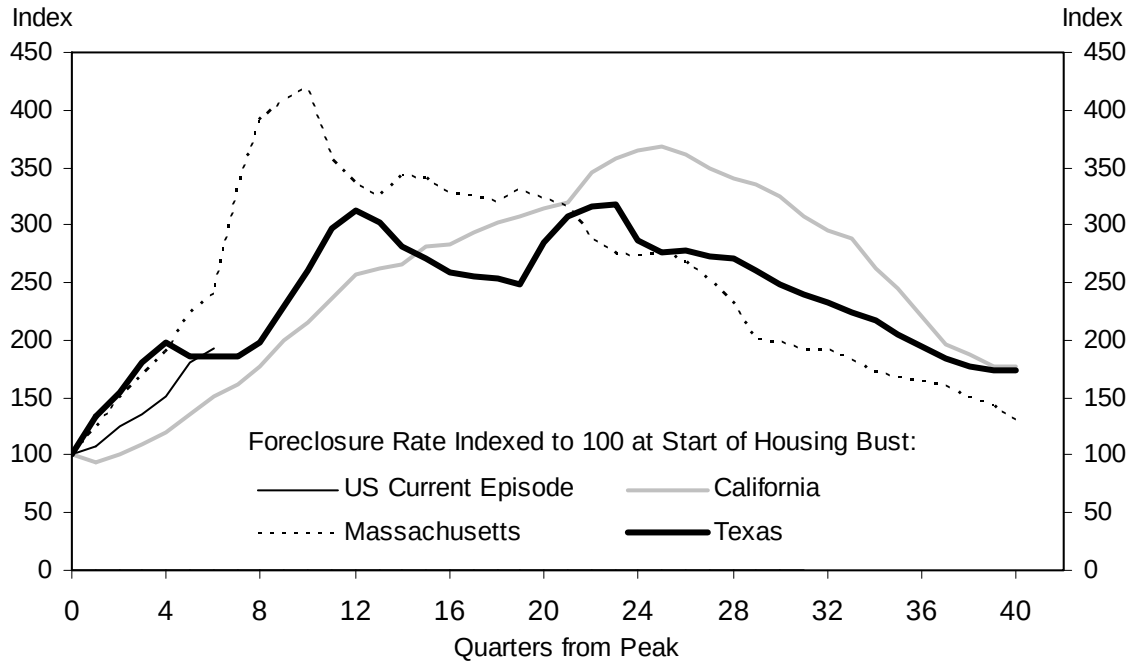
* 4-quarter moving average.
Source: Mortgage Bankers Association. OFHEO.

Exhibit 3.6 summarizes the experience of the three regional housing busts by indexing the foreclosure rate at the beginning of the episode to 100 and then tracing its evolution over the following decade. The average rate triples within several years, and this same tripling holds for each of the individual states. After peaking between years 2 and 6,

foreclosures gradually fall back towards the original level. Moreover, the chart shows that the initial experience with the national foreclosure rate in the first year of the current downturn is roughly consistent with what we saw in the typical regional housing bust episode.

To get an estimate of future U.S. defaults and losses under a scenario of 10–15% peak-to-trough decline in home prices (as measured by the OFHEO index), we could simply apply the pattern of Exhibit 3.6 to the national data. One might argue that this analysis is too pessimistic because California, Massachusetts, and Texas all saw statewide recessions during their housing market downturn. Nationally, a recession is very possible, but it is not a foregone conclusion at this point. However, we believe that the potentially more resilient macroeconomy is likely to be offset by two factors that point to a more difficult environment than in the statewide downturns. First, credit standards as measured by loan to value ratios or debt service to income ratios were much looser in recent years than in the 1980s and early 1990s. Second, resets on adjustable-rate mortgages are likely to exert a bigger drag on household finances in coming years than they did in the regional housing busts of the early 1990s. This suggests that the pace of the mortgage credit deterioration could rival that seen in the regional housing busts, even if the national economy avoids a serious recession.

Exhibit 3.6 Foreclosures Triple in the Housing Bust



Source: Mortgage Bankers Association.

Hence, we conclude from our analysis that a housing downturn that resembled the three regional busts, with a 10–15% peak-to-trough home price fall, could triple the national foreclosure rate over the next few years. This would imply a rise from 0.4% in mid-2006

to 1.2% in 2008 or 2009. Once home prices recover, the foreclosure rate might gradually fall back toward 0.4%.

So what does this mean for the total amount of mortgage credit losses over the next few years? To calculate the incremental defaults, we cumulate the differences between the projected foreclosure rate and the 0.4% rate prevailing at the start of the downturn in mid-2006 over the entire 2006-2013 period. This is a simple way of adjusting for the fact that this framework does not allow us to isolate defaults on the stock of mortgages outstanding in February 2008 from defaults on mortgages that have yet to be originated. We believe this is a conservative choice, as quality standards on mortgages originated over the next few years are likely to return to the pre-2004 levels. Hence, the vast majority of the defaults in coming years are likely to involve mortgages originated up to 2007.

These assumptions imply cumulative "excess" foreclosures of 13.5% of the currently outstanding stock of mortgages over the next few years.[11] On a base of $11 trillion of 1-4 family mortgage debt, this implies cumulative foreclosure starts of $1.5 trillion. Not every mortgage entering the foreclosure process will end up as an outright repossession, as some homeowners will manage to become current on their payment, sell, or refinance before the home is repossessed. However, the percentage of all foreclosure starts that turn into repossessions – measured by the number of Real Estate Owned (REO) notices divided by the lagged number of Notices of Default (NoD) – rose to 68% in the first quarter of 2008 according to Data Quick, Inc., a real estate information company. Assuming that repossessions continue to average about two-thirds of all initiated foreclosures and the average loss severity is 50%, as is typical in a depressed housing market, we calculate that $1.5 trillion of foreclosure starts could translate into mortgage credit losses of about $500 billion.[12] Moreover, if home prices fall by more than the 10–15% drop seen in the California, Massachusetts, and Texas busts, the losses could be significantly larger.

We conclude from our review that total mortgage credit losses on the currently outstanding stock of mortgages could total around $500 billion. This is somewhat more than implied by most vintage-by-vintage analyses, unless these are adjusted aggressively for structural changes resulting from the decline in home prices, approximately in line with the losses implied by the ABX indexes (once we adjust the latter for losses on non-subprime mortgages), and somewhat less than the losses suggested by our state-by-state analysis (once we adjust this analysis for the likely larger home price decline). We reiterate that the uncertainty around our estimate is undoubtedly very high.

[11] The calculation is that the foreclosure rate exceeds its baseline level by an average of 0.48 percentage points per quarter for a 7-year period, which implies cumulative excess foreclosures of 13.5%.

[12] The Goldman Sachs (2007) analysis cited previously assumes that severities on recently originated subprime loans will reach 60%. We use the slightly more conservative 50% figure to account for the fact some will occur on non-subprime loans, which are typically larger and where the administrative costs of repossessing and selling the home are therefore smaller in percentage terms.

3.4 Allocating the losses

To allocate the losses to different types of institutions, we rely on two sources of information: 1) top-down data on the mortgage exposures of different sectors and 2) bottom-up data on announced and estimated subprime exposures by company. In these calculations we exclude any losses on synthetic securities (such as credit default swaps), and this is important to recognize in comparing our estimates with others.

We first use data from the Federal Reserve Board and the Federal Deposit Insurance Corporation to allocate the total outstanding mortgage debt to different sectors. For each part of the "leveraged sector" – banks, savings institutions, credit unions, investment banks, government-sponsored enterprises, and finance companies – we add direct holdings of mortgages backed by 1-4 family homes and holdings of residential mortgage-backed securities (RMBS). Direct mortgage holdings by different sectors are available from the Federal Reserve's Flow of Funds accounts. Holdings of RMBS by commercial banks and savings institutions are available from the FDIC. However, we need to estimate holdings of RMBS by credit unions, investment banks, and government-sponsored enterprises – which are not broken out separately in the Flow of Funds or FDIC data – by extrapolating from the asset-backed securities on their balance sheets and the share of RMBS in the total amount of outstanding asset-backed securities. As shown in Exhibit 3.7 below, our top-down calculation suggests that US leveraged institutions hold 55% of all outstanding mortgage debt, either directly or via RMBS.

Our second approach relies on data from Goldman Sachs (2007) that are based on mortgage issuance, default, and prepayment data to calculate exposures to subprime mortgages across a broad range of leveraged and unleveraged institutions. We have made several adjustments to these data in order to estimate the share of all exposures held by U.S. as opposed to foreign leveraged institutions. First, we have reclassified $95 billion of subprime mortgage exposure held in the form of direct subprime loans by Household Finance, the U.S. subsidiary of HSBC, as a U.S. rather than a foreign exposure. This is because our definition of U.S. institutions in the macro data includes the U.S. subsidiaries of foreign banks. To the extent that the data for other foreign banks may also include exposures held by their U.S. subsidiaries, our estimates may understate the share of subprime exposures held by U.S. leveraged institutions.

Exhibit 3.7: Home Mortgage Exposures of US Leveraged Institutions

Home Mortgage Debt	Billion ($)
Total	**11,136**
US Leveraged Institutions	**6,134**
Commercial banks	**2,984**
Direct	2,012
RMBS	971
Savings Institutions	**1,105**
Direct	840
RMBS	265
Credit Unions	**351**
Direct	311
RMBS (estimate)	40
Brokers and Dealers	**257**
Direct	0
RMBS (estimate)	257
Government-Sponsored Enterprises	**963**
Direct	445
RMBS (estimate)	519
Finance Companies	**474**
Direct	474
RMBS	0

Source: Federal Reserve Board. FDIC. Authors' calculations.

Second, we need to decide what percentage of hedge fund exposures estimated by the GS analysts refers to U.S. as opposed to foreign hedge funds. Unfortunately, no good information is available on this issue. However, we believe it is safe to assume that U.S. hedge funds account for most subprime mortgage exposures by hedge funds globally and so we assume their share is 80%.

As shown in Exhibit 3.8 below, our bottom-up analysis implies that U.S. leveraged institutions account for 49% of all identified subprime mortgage exposures. (Note that these data say nothing about exposures to non-subprime mortgage debt.) Based on these data and the top-down estimates shown in Exhibit 3.7, we estimate that roughly 50%, or $250 billion, of our $500 billion estimate of credit losses on the currently outstanding stock of mortgages will hit U.S. leveraged institutions.[13]

[13] In Exhibit 3.8 we have not included the finance companies as part of the leveraged sector. Finance companies are not banks in the traditional sense, but arguably, they could be subject to the same forces in the adjustment of balance sheets. If we were to include finance companies in the leveraged sector the estimated impact of deleveraging to be reported below will be even higher.

Exhibit 3.8 Subprime Mortgage Exposures, Bottom-Up

	Total reported sub-prime exposure	Percent of reported exposure
US Investment Banks	75	5%
US Commercial Banks	250	18%
US GSEs	112	8%
US Hedge Funds	233	17%
Foreign Banks	167	12%
Foreign Hedge Funds	58	4%
Insurance Companies	319	23%
Finance Companies	95	7%
Mutual and Pension Funds	57	4%
US Leveraged Sector	671	49%
Other	697	51%
Total	1,368	100%

Note: The total for U.S. commercial banks includes $95 billion of mortgage exposures by Household Finance, the U.S. subprime subsidiary of HSBC. Moreover, the calculation assumes that U.S. hedge funds account for four-fifths of all hedge fund exposures to subprime mortgages.
Source: Goldman Sachs. Authors' calculations.

4. Leverage and Amplification

We now attempt to reconcile the evidence presented in the last two sections. In doing so, we focus on three questions. First, can we understand how a shock of roughly $250 billion to the leveraged intermediary sector might cause the type of turmoil that we have documented? Second, can we simultaneously explain why other markets were not initially disturbed? Finally, what will the credit losses imply for lending by the intermediaries?

4.1 The mechanics of active balance sheet management

The first ingredient in our explanation relates to the risk management practices of modern financial intermediaries. Financial intermediaries manage their balance sheets actively in response to changes in anticipated risk and asset prices. When balance sheets are marked to market, asset price changes show up as changes in net worth, and elicit reactions from financial intermediaries to changes in their net worth. Even in the absence of asset price changes, shifts in perceived risks will also elicit reactions from leveraged institutions. Moreover, financial intermediaries react in a very different way to the fluctuations in net worth as compared to households or non-financial firms. Indeed, there is a wealth of evidence dealing with the role of home prices in the monetary transmission mechanism (see Mishkin (2007)). However, households tend not to adjust their balance sheets drastically to changes in asset prices. In general, leverage *falls* when total assets rise. For households, the change in leverage and change in balance sheet size are negatively correlated.

However, the picture for financial intermediaries is very different. There is a *positive* relationship between changes in leverage and changes in balance sheet size. Far from being passive, financial intermediaries adjust their balance sheets actively and do so in such a way that leverage is high during booms and low during busts. Leverage is procyclical in this sense (Adrian and Shin (2007,8)). For financial intermediaries, their models of risk and economic capital dictate active management of their overall value at risk (VaR) through adjustments of their balance sheets. Value at risk is a numerical estimate of an institution's "approximately" worst case loss, in the sense that anything beyond this worst case loss happens only with some benchmark probability.

Denoted by V, the value at risk per dollar of assets held by a bank.[14] The total value at risk of the bank is given by $V \times A$ where A is total assets. Then, if the bank maintains capital E to meet total value at risk, we have $E = V \times A$. Hence, leverage L satisfies

$$L = A/E = 1/V$$

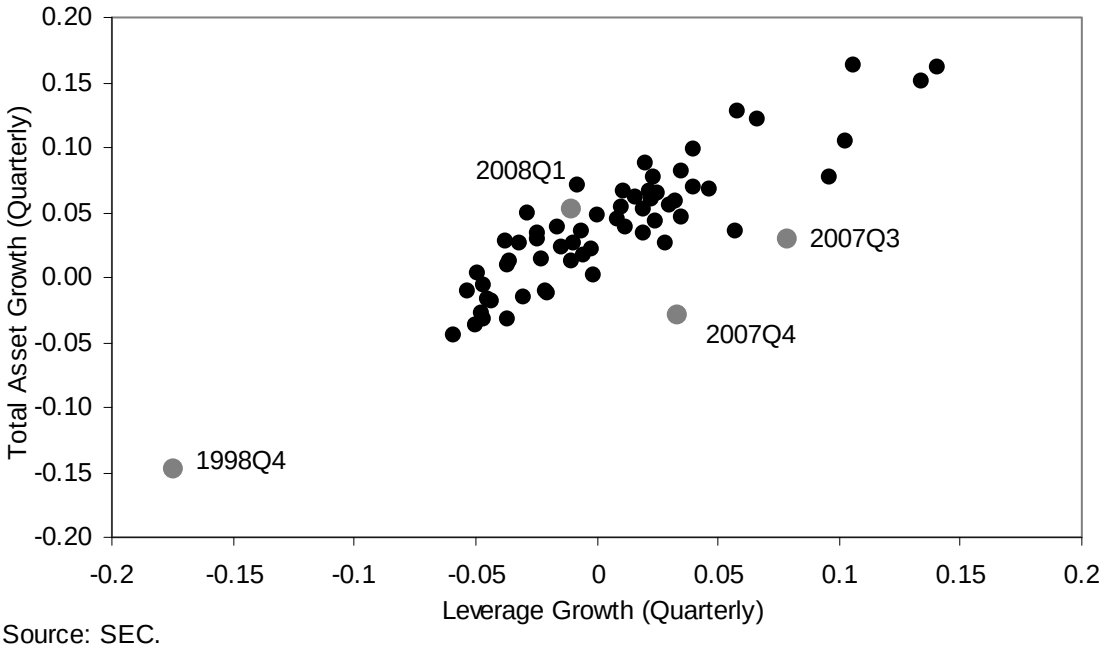
Procyclical leverage can be traced directly to the counter-cyclical nature of value at risk. Leverage is high when values at measured risks are low – which occurs when financial conditions are buoyant and asset prices are high. Leverage is low in the troughs of the financial cycles, reflecting increased volatility of asset prices as well as increased correlation of asset returns.

Exhibit 4.1 below plots the value-weighted quarterly change in leverage and change in assets for the five major U.S. investment banks up to 2008 Q1.[15] Leverage is defined as the ratio of total assets to book equity. Two features stand out. First, leverage is procyclical. Leverage increases when balance sheets expand, and leverage falls when balance sheets contract. Second, there is a striking contrast between the observation for 1998 Q4 associated with the LTCM crisis and the credit crisis that began in 2007. While balance sheets contracted sharply in 1998, there had not (at least through 2008 Q1) been a comparable contraction of balance sheets during this latest crisis. Indeed, it is one of our central contentions that understanding the reasons for the difference between 1998 and 2007 holds the key to unlocking some of the mysteries surrounding the severe pressures evident in the interbank credit market during the period from August 2007 to the spring of 2008.

[14] Formally, the value at risk (VaR) associated with some time horizon T is the smallest non-negative number V such that the estimated probability that a bank's loss is greater than V is less than some benchmark probability p. Value at risk is used widely by financial institutions and by regulators, and is incorporated into the Basel capital rules. We use "value at risk" to include the expected losses as well as the unexpected losses. Thus, V should be seen as including the expected losses.

[15] Bear Stearns, Goldman Sachs, Lehman Brothers, Morgan Stanley and Merrill Lynch, 1991Q1 – 2008Q1. The panel is unbalanced, since not all of these firms were public through the sample period.

Exhibit 4.1: Quarterly Changes in Assets and Leverage of U.S. Investment Banks



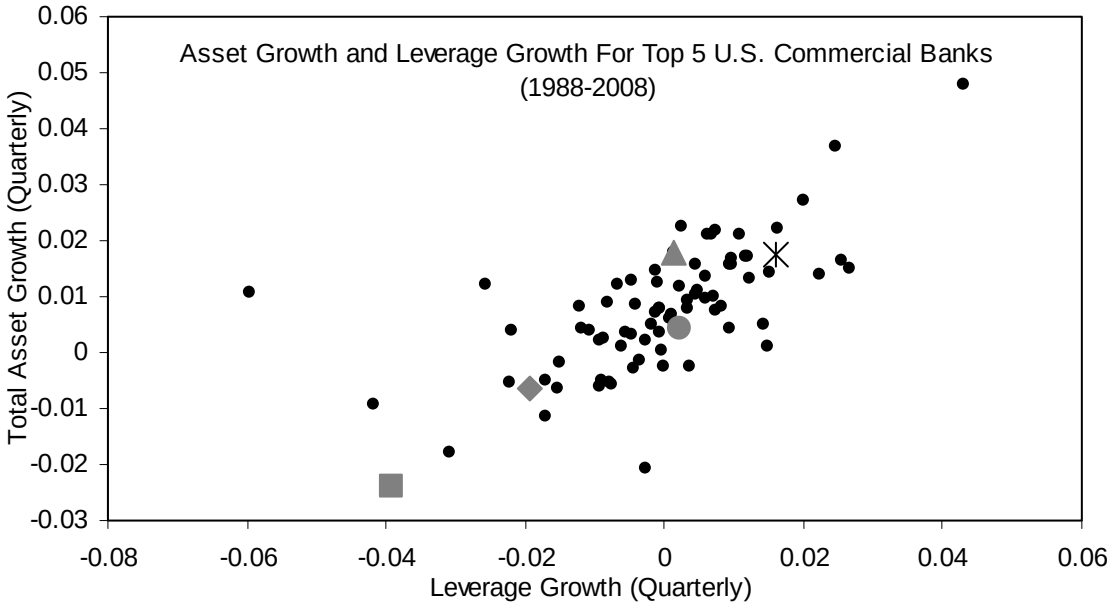
Source: SEC.
Note: Growth rates are assets-weighted.

The leverage ratios of commercial banks is typically much lower – at around 10-12 – than that of investment banks (which have leverage ratios of roughly 20–25). However, the relationship between total assets and leverage reveals a similar picture to that given by the investment banks. Exhibit 4.2 plots the relationship between the quarterly change in total assets and the quarterly change in leverage for the five largest U.S. commercial banks – Bank of America, JP Morgan Chase, Citibank, Wachovia and Wells Fargo – over the period 1988 Q1 to 2008 Q1. One important issue that arises in studying the banks is that each of them has been involved in multiple mergers and acquisitions over this period, so we have adjusted the data to remove these effects.[16]

Commercial banks also exhibit the positive relationship between changes in assets and changes in leverage. Investment bank balance sheets consist largely of very short term claims (such as repurchase agreements and reverse repurchase agreements), so that their balance sheet values approximate the marked-to-market values of the underlying securities. The same is not true for the commercial bank balance sheets, since loans are carried at face value. Thus, the scatter chart for commercial banks should be interpreted with some caution. Nonetheless, it is interesting to see that through 2008 Q1 the commercial banks had also not shown signs of deleveraging and in fact leverage actually rose in the first quarter of 2008. This stands in contrast to the experience in the past two recessions, where there was at least one quarter during which shrinking balance sheets were accompanied by falling leverage.

[16] For instance, if banks A and B merge in quarter t so that bank B disappears, we compute the growth rate in assets and leverage by forming a combined bank in quarter t-1.

Exhibit 4.2 Changes in Leverage and Assets for Major U.S. Commercial Banks



Note: Data are adjusted for mergers. Grey triangle = 9/30/2007, Grey circle = 12/31/2007, Grey square = 12/31/2001, Grey diamond = 12/31/1990. Asterisk = 3/31/08.

The adjustment of leverage has aggregate consequences that may lead to the amplification of the financial cycle. Consider a simple example. Take a financial intermediary that manages its balance sheet actively so as to maintain a constant leverage ratio of 10. The hypothesis that the intermediary has a constant leverage target is for clarity of the illustration only. Our numerical estimates on credit contractions that follow later in the report recognize the possible role of deleveraging.

Thus, for this illustration only, suppose that the intermediary targets constant leverage of 10. Suppose the initial balance sheet is as follows. The intermediary holds 100 worth of assets (securities, for simplicity) and has funded this holding with debt worth 90.

Assets	Liabilities
Securities, 100	Equity, 10
	Debt, 90

Assume that the price of debt is approximately constant for small changes in total assets. First, let's assume the price of securities increases by 1% to 101.

Assets	Liabilities
Securities, 101	Equity, 11
	Debt, 90

Leverage then falls to 101/11 = 9.18. If the bank targets leverage of 10, then it must take on additional debt of D to purchase D worth of securities on the asset side so that

$$\text{assets / equity} = (101 + D)/11 = 10$$

The solution is $D = 9$. The bank takes on additional debt worth 9, and with the proceeds purchases securities worth 9. Thus, an increase in the price of the security of 1 leads to an increased holding worth 9. The demand curve is upward-sloping. After the purchase, leverage is now back up to 10.

Assets	Liabilities
Securities, 110	Equity, 11
	Debt, 99

The mechanism works in reverse, on the way down. Suppose there is shock to the securities price so that the value of security holdings falls to 109. On the liabilities side, it is equity that bears the burden of adjustment, since the value of debt stays approximately constant.

Assets	Liabilities
Securities, 109	Equity, 10
	Debt, 99

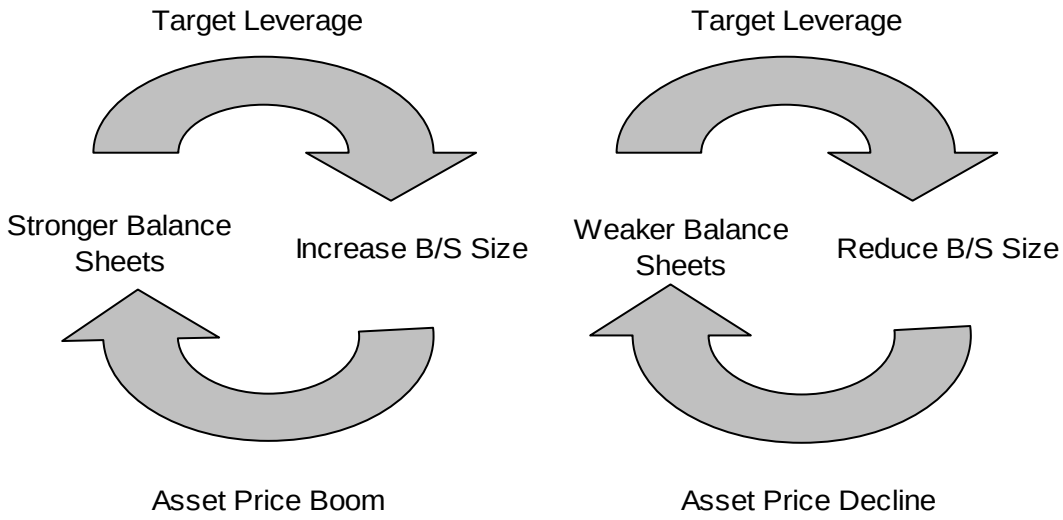
Leverage is now too high (109/10 = 10.9). The bank can adjust down its leverage by selling securities worth 9, and paying down 9 worth of debt. In this way, a fall in the price of securities leads to sale of securities. The supply curve is downward-sloping. The new balance sheet is hence restored to where it stood before the price changes and leverage is back down to the target level of 10.

Assets	Liabilities
Securities, 100	Equity, 10
	Debt, 90

Leverage targeting entails upward-sloping demands and downward-sloping supplies. The perverse nature of the demand and supply curves is even stronger when the leverage of the financial intermediary is pro-cyclical — that is, when leverage is high during booms and low during busts. If, in addition, there is the possibility of feedback, then the

adjustment of leverage and of price changes will reinforce each other in an amplification of the financial cycle.

Exhibit 4.3 The Leverage Circle



If greater demand for the asset tends to put upward pressure on its price, then there is the potential for feedback in which stronger balance sheets trigger greater demand for the asset, which in turn raises the asset's price and leads to stronger balance sheets. The mechanism works in reverse in downturns. If greater supply of the asset tends to put downward pressure on its price, then weaker balance sheets lead to greater sales of the asset, which depresses the asset's price and leads to even weaker balance sheets.

The balance sheet perspective gives new insights into the nature of financial contagion in the modern, market-based financial system. Aggregate liquidity can be understood as the rate of growth of aggregate balance sheets. When financial intermediaries' balance sheets are generally strong, their leverage is too low. The financial intermediaries hold surplus capital, and they will attempt to find ways in which they can employ their surplus capital. In a loose analogy with manufacturing firms, we may see the financial system as having "surplus capacity". For such surplus capacity to be utilized, the intermediaries must expand their balance sheets. On the liabilities side, they take on more short-term debt. On the asset side, they search for potential borrowers that they can lend to. Aggregate liquidity is intimately tied to how hard the financial intermediaries search for borrowers. With regard to the subprime mortgage market in the United States, we have seen that when balance sheets are expanding fast enough, even borrowers who do not have the means to repay are granted credit — so intense is the urge to employ surplus capital. The seeds of the subsequent downturn in the credit cycle are thus sown.

4.2 The implications of active balance sheet management

The amplification mechanism driven by leverage adjustments sheds light on two key features of the current credit crisis.

- First, the early phase of the crisis presented a tale of divergence between those markets that suffered acute distress — such as the interbank funding market and mortgage-related markets, such as asset backed commercial paper (ABCP), collateralized debt obligations (CDOs) and jumbo mortgages. But, the stock market and the markets for sovereign debt and high grade corporate bonds remained relatively unscathed through the early stages of the crisis.
- Second, the current credit crisis began with the deterioration in the credit quality of subprime mortgages in the United States. However, we have seen that, by most measures, the total size of expected losses from credit exposures is small relative to other benchmarks, such as household sector net worth or total stock market capitalization. And yet, the anticipated losses have caused large disruptions.

The key to both features lies in the identity of the holders of the different asset classes in the financial system. Take the case of the stock market. Total U.S. equity holdings (including foreign stocks) stands roughly at $23 trillion. However, only a small fraction (less than 1.3%) of this total is held by leveraged players, such as banks and broker dealers. Most stocks are held by non-leveraged investors – either directly by households, or indirectly through long-only financial institutions such as mutual funds and insurance companies. For households and long-only investors, their reactions to the waxing and waning of balance sheets tend to be passive.

Consistent direct data on sovereign debt holdings by different entities are difficult to obtain. Conventional wisdom suggests that sovereign debt is held by long-only institutions that act as hold-to-maturity investors rather than being held by leveraged institutions that manage their balance sheets actively. Based on footnotes in the annual reports of investment banks, this can be confirmed in a couple of cases.[17]

For corporate debt, it is important to distinguish the cash bonds themselves from the over-the-counter derivatives that have been written on them — such as the credit default swaps. Even among the cash bonds, it may be important to distinguish the holders of high grade corporate debt from the holders of speculative grades. For high grade bonds, conventional wisdom suggests that these are owned mainly by hold-to-maturity investors, who are not particularly sensitive to changes in their balance sheet size.

In contrast, mortgages and asset-backed securities built on mortgage assets are held in large quantities by leveraged institutions — by the broker-dealers themselves at the warehousing stage of the securitization process, by hedge funds specializing in mortgage securities, and by the off-balance-sheet vehicles that the banks had set up specifically for the purpose of carrying the mortgage securities and the collateralized debt obligations that have been written on them. According to the Federal Reserve's Flow of Funds

[17] As of the end of the 2006 fiscal year, Morgan Stanley reported that 7.2% of the financial instruments owned and securities sold but not yet purchased was sovereign debt. Bear Stearns had 0.3%. Lehman Brothers and Goldman Sachs do not separately show sovereign holdings.

accounts, banks and thrifts held 37% of mortgage debt at the end of the third quarter of 2007.

More importantly still, mortgage-related losses of $250 billion for the financial intermediaries would be quite substantial in comparison to their capital. Below, we provide calculations to document this claim and then explore the endogenous effect that these losses could have on the lending by the intermediaries.

Referring back to Exhibit 4.1, the scatter chart for the U.S. investment bank assets and leverage, we note the contrast between the observations for 1998 Q4 and those for 2007 Q3, 2007 Q4 and 2008 Q1. During the LTCM crisis of 1998, both leverage and balance sheet size contracted very sharply, as we see on the bottom-left corner of the chart. Such a move is consistent with increased value at risk and the desire by the financial intermediaries to conserve capital in the face of heightened uncertainty.

The four major investment banks reported the average daily VaR over the last three months in each of their quarterly SEC filings. Exhibit 4.4 shows these data since May 2006. Through February 2008, VaR had more than doubled relative to May 2006. At the same time, balance sheets had not shrunk.

Exhibit 4.4 Reported Average Daily Value at Risk over the previous 3 months

	May-06	Aug-06	Nov-06	Feb-07	May-07	Aug-07	Nov-07	Feb-08
Index of VaR	1.00	0.89	1.05	1.29	1.38	1.58	1.95	2.12

Source: Authors' calculations using reported figures from Bear Stearns, Goldman Sachs, Lehman Brothers, and Morgan Stanley. Note data for Goldman Sachs are missing for November 2006.

Together these two observations are puzzling. Given what we know about how financial intermediaries behave, we would have expected the 2008 Q1 observation to be in the bottom-left corner of Exhibit 4.1 – near the 1998 Q4 observation. The fact that it is not in the bottom-left corner suggests that other factors are preventing the banks from making such an adjustment.

One conjecture is that off-balance-sheet vehicles such as conduits and SIVs (structured investment vehicles) have played an important role in the current crisis. Conduits and SIVs were designed to hold mortgage-related assets funded by rolling over short-term liabilities such as asset-backed commercial paper (ABCP). However, during the initial stages of the crisis (roughly mid-August 2007) they began to experience difficulties in rolling over their ABCP liabilities. Many of the off-balance-sheet vehicles had been set up with back-up liquidity lines from commercial banks, and such liquidity lines were beginning to be tapped by mid-August.

As credit lines were tapped, the balance sheet constraint at the banks must have begun to bind, making them more reluctant to lend. In effect, the banks were "lending against their will". The fact that bank balance sheets did not contract is indicative of this involuntary expansion of credit. One of the consequences of such an involuntary expansion was that banks sought other ways to curtail lending. Their natural response

was to cut off, or curtail, lending that was discretionary. The seizing up of the interbank credit market can be seen as the conjunction of the desired contraction of balance sheets and the "involuntary" lending due to the tapping of credit lines by distressed entities.

Other factors, such as concerns over counterparty risk and the hoarding of liquidity in anticipation of new calls on the capital of the bank would certainly have exacerbated such trends. However, the hypothesis of an "involuntary" extension of credit appears important in explaining some of the salient features of recent credit market events.

4.4 Deleveraging

Our analysis suggests that the current crisis will abate once one or more of the following three conditions are met.

1. **Either,** banks and brokers contract their balance sheets sufficiently that their capital cushion is once again large enough to support their balance sheets.
2. **Or,** banks and brokers raise sufficient new equity capital to restore the capital cushion to a size large enough to support their balance sheets
3. **Or,** the perceptions of risk change to a more benign outlook so that the current level of leverage can once again be supported with existing capital.

Our working hypothesis is that (3) has not yet happened, although the acute phase of the crisis that reached a peak with the run on Bear Stearns in March has given way to somewhat more orderly market conditions. Although we cannot rule out (3) altogether, we believe options (1) and/or (2) to be more plausible as the mechanism that will bring leverage back into line.

The most optimistic scenario would be (2), i.e., new equity is raised from investors. We have seen substantial amounts of new capital raised so far. In fact, as of May 20, 2008, write-downs announced by about 60 banks and brokerage firms (including numerous non-U.S. institutions) totaled $381 billion, while new capital injections amounted to $266 billion.[18] For US firms only, write-downs were $162 billion while capital injections had reached $138 billion. Of course, some losses were borne by the US subsidiaries of foreign firms and thus the volume of write-downs and associated recapitalization relevant for our purposes is somewhere between the global total and the US-only amount. The extent of the decline in credit will depend on the combination of the ultimate losses suffered by banks and the amount of new capital they can raise. In the remainder of this section we explore the various ways in which deleveraging might occur.

In doing so, we will trace the change in "aggregate assets" for the leveraged sector. The logic of the foregoing analysis points to tracking something akin to the sum across all leveraged institutions of their total assets. This can be thought of as the total lending provided by the leveraged sector. But this construct involves a double-counting of assets held by a leveraged institution against another leveraged institution. For instance, a bank

[18] These figures are based on public announcements of write-downs and recapitalizations compiled by Bloomberg (see page WDCI<GO>).

that holds bonds issued by Fannie Mae counts these bonds on the asset side of its balance sheet, but the bonds are a claim held against an entity *within* the leveraged sector.

Adjustments of claims between leveraged institutions in principle need not spill over to the real economy. To identify these spillovers we are interested in the leveraged sector's total claims against other sectors (such as households and corporates). We will refer to these claims as the "aggregate end-user assets" of the leveraged sector.

To see how the adjustments of aggregate assets and aggregate end-user assets are related, denoted by *A*, the initial aggregate assets of the leveraged sector, and denoted by *A** the aggregate assets of the leveraged sector after the adjustment of balance sheets. We denote by *E* the initial equity of the leveraged sector, and by *E** the equity of the leveraged sector following the credit losses, and augmented by recapitalizations (if any).

We will allow for the leverage ratio to change in our hypothetical examples, to reflect possible shifts in the stance of banks toward measured risks. We denote by μ the ratio of the new leverage to the old leverage. In other words,

$$\frac{A^*}{E^*} \equiv \mu \times \frac{A}{E}$$

Denoted by *L*, the total credit losses suffered by the leveraged financial sector as a whole, and denoted by *k* the proportion of total credit losses that are made up by the raising of new capital. Hence, the shrinkage in total assets of the leveraged sector can be expressed in terms of the ratio:

$$\frac{A^*}{A} = \mu \times \frac{E^*}{E} = \mu \times \left(1 - \frac{L(1-k)}{E}\right)$$

In order to make further progress on estimating the shrinkage of total assets, we need estimates of the parameters. We acknowledge the uncertainty that surrounds μ and *k* by tabulating our estimates for different combinations of these two parameters.

We are on slightly firmer ground regarding the other two parameters, namely *L* and *E*. From our earlier calculations, we believe that a reasonable estimate of *L* (the losses suffered by the leveraged sector as a whole) is $250 billion. We will work out an estimate of *E* by calculating the total assets of the leveraged sector and its overall leverage.

First, let us come to an estimate of the total balance sheet size of the leveraged financial sector as a whole. For this, we take account of the following figures.

- The total financial assets of the U.S. commercial banking sector stood at $11.194 trillion at 2007 Q4, according to the Federal Reserve's Flow of Funds accounts.
- Adrian and Shin (2007) estimate the combined total size of balance sheets of the brokerage sector and hedge fund sector to be just over 50% of the commercial banking sector. Thus, as a very conservative figure, we may put

a lower bound on the size of the combined broker-dealer and hedge fund sector at half of the total commercial bank balance sheet, or $5.597 trillion.

- We also include the total assets of Fannie Mae and Freddie Mac, which stood at $1.669 trillion.
- Finally, we include the total assets of savings institutions and credit unions ($1.815 trillion and $759 billion, respectively).

Summing these figures, we arrive at an estimate for the total assets of leveraged institutions of $22.945 trillion. In what follows, we will use the rounded figure of $23 trillion, as our estimate of leveraged institutions' total assets.

We now turn to the calculation of leverage. The leverage ratios of the different classes of financial institutions vary widely, as is clear from Exhibit 4.5.[19]

Exhibit 4.5 Leverage of Various Financial Institutions

	Assets ($bn)	Liabilities ($bn)	Capital ($bn)	Leverage
Commercial banks	11194	10050	1144	9.8
Savings Inst	1815	1607	208	8.7
Credit Unions	759	672	87	8.7
Finance Companies	1911	1720	191	10.0
Brokers/hedge funds	5597	5390	207	27.1
GSEs	1669	1598	71	23.5
Leveraged Sector	**22945**	**21037**	**1908**	**12.0**

Source: Authors' calculations based on Flow of Funds, FDIC Statistics on Banking, Adrian and Shin (2007), and balance sheet data for Fannie Mae, Freddie Mac, and broker-dealers under Goldman Sachs equity analysts' coverage.

Given the wide dispersion in the leverage figures, we will be conservative and choose the round figure of 10 for leverage. This figure is very close to the leverage ratio for commercial banks.

Exhibit 4.6 lists the ratio A^*/A in a two-dimensional tabular form as combinations of different values of k (the proportion of losses recouped by raising new capital) and the desired reduction in leverage. We list three cases — the first is where there is no change in desired leverage, which corresponds to $\mu = 1$, the second is where there is a 5% decline in desired leverage, and the final case is when there is a 10% decline in desired leverage. As we have seen from our scatter charts, experience suggests that changes in leverage can be quite substantial. Thus, although the outcome is very uncertain, we see the 0–10% range as covering the plausible range of declines in leverage. We maintain the

[19] In Exhibit 4.5, the liabilities of credit unions is shown so that leverage of credit unions is set equal to that of savings institutions. Finance company liabilities are imputed to produce a leverage estimate of 10.

assumption that L is $250 billion, and we set E = $2.3 trillion, reflecting our estimate of total assets of $23 trillion, and initial leverage of 10.

Exhibit 4.6 Aggregate Asset Contraction as a Fraction of Initial Assets

		Decline in Leverage		
		0%	**5%**	**10%**
	100%	1.00	0.95	0.90
	75%	0.97	0.92	0.88
k	**50%**	0.95	0.90	0.85
	25%	0.92	0.87	0.83
	0%	0.89	0.85	0.80

Exhibit 4.7 translates the proportional contractions in total credit into dollar figures, using our initial estimate of total assets of $23 trillion dollars.

Exhibit 4.7 Total Asset Contraction ($Trillion) Associated with Deleveraging

		Decline in Leverage		
		0%	**5%**	**10%**
	100%	0.00	1.15	2.30
	75%	0.63	1.74	2.86
k	**50%**	1.25	2.34	3.43
	25%	1.88	2.93	3.99
	0%	2.50	3.53	4.55

Shading indicates baseline scenario.

The raw numbers are substantial, especially for the bottom-right cells of the table that correspond to reductions in leverage, combined with meager recapitalization of the leveraged sector losses.

Our baseline scenario (marked in grey) is that leverage will decline by 5%, and that recapitalization of the leveraged system will recoup around 50% of the $ 250 billion loss incurred by the banking system. Under this baseline scenario, the total contraction of balance sheets for the financial sector is $2.34 trillion.

Although the degree of recapitalization is uncertain, it is notable that our estimate for the contraction of balance sheets is not particularly sensitive to the choice of *k.* For instance, if *k* were to turn out to be 25% rather than 50%, the contraction would be only somewhat larger (at $2.93 trillion) than our benchmark case. Alternatively, if *k* were to turn out to be 75% rather than 50%, the contraction would fall to $1.74 trillion.

Calibrating the baseline estimate for the change in leverage is more challenging. As shown in both Exhibits 4.1 and 4.2, there have been occasions in the past when the leverage of intermediaries has shrunk by more than 5%. One reason for choosing this as the reference point is the "lending against their will" phenomenon noted earlier. Because leverage actually increased for both large investment banks and commercial banks during 2007, some of the contraction from that point forward is required just to move back towards the target value that had been obtained before the crisis. Given the more than

50% increase in Value at Risk relative to a year earlier, the 5% assumption strikes us as conservative. But this baseline is admittedly arbitrary. Unfortunately, as can be seen by scanning across any row in the table, the implied size of the contraction is more sensitive to this assumption than to the one on *k*.

So far, we have examined the contraction in total assets of the leveraged sector, which includes a large degree of double-counting of claims that one leveraged institution holds against another one. For the overall economic impact of credit contraction associated with the end-users of credit (such as households and corporates), we must separate the overall contraction of balance sheets into those that affect other leveraged institutions, and those that affect households and firms.

The rationale behind such a calculation rests on the overall leverage of the financial intermediary sector as a whole. More concretely, it is helpful to write out a stylized balance sheet of a leveraged institution:

Assets	Liabilities
s	*d*
y	*h*
	e

Here, *s* denotes claims on other leveraged parties — such as a bank's holding of Fannie Mae bonds (the "*s*" stands for "securities"). Loans to end-users outside the leveraged sector are denoted by *y*. On the liabilities side, the institutions have obligations to other leveraged institutions (*d*), obligations to non-leveraged entities (*h*) and equity (*e*).

Let capital letters corresponding to these items be the sum across the set of all leveraged institutions. Thus, $S = \sum_i s_i$ and $Y = \sum_i y_i$ etc. Then, we have

$$A = S + Y = D + H + E$$

The important point for us is that the claims and obligations between leveraged institutions cancel out when summed. In other words, $S = D$. This is intuitive since it reflects the fact that the total loans to end-users *Y* must either be funded through the equity of the banking system *E*, or must come from outside the banking system through *H*. Hence,

$$Y = H + E$$

Define the ratio of deposits to total assets as:

$$z = \frac{H}{A}$$

Let $\lambda = A/E$ denote aggregate leverage. Then, we have

$$\frac{H}{E} = \frac{H}{A} \times \frac{A}{E} = z\lambda$$

Hence,

$$\begin{aligned} Y &= E + H \\ &= E\left(1 + \frac{H}{E}\right) \\ &= E(1 + z\lambda) \end{aligned}$$

Thus, if we know *z* (the ratio of deposits of non-leveraged entities to total assets), we can estimate the ratio of the decline in credit to end-users to the decline in total assets from:

$$\frac{Y}{A} = \frac{Y/E}{A/E} = \frac{1 + z\lambda}{\lambda}$$

Exhibit 4.8 shows Flow of Funds data on currency and deposit holdings of various sectors as of 2007 Q4.

Exhibit 4.8 Total Deposits held by Non-Financial Entities

	($bn)
Checkable deposits and currency, personal sector	468
Time and saving deposits, personal sector	6,335
Checkable deposits and currency, nonfin corp	161
Time and saving deposits, nonfin corp	392
Checkable deposits and currency, public sector	112
Time and saving deposits, public sector	248
Total	7,716

Source: Federal Reserve, Flow of Funds accounts.

From the total of $7.716 trillion we need to subtract currency holdings. Total U.S. currency in circulation, as of 2007 Q4, was $774 billion. If we assume that three quarters of U.S. currency is held abroad,[20] currency holdings would be around $194 billion, which would give us about $7.522 trillion for total deposits.

Using our earlier estimate of $23 trillion for total assets of the leveraged sector, we arrive at a figure for *z* of 0.327, and our ratio $(1 + z\lambda)/\lambda$ of 0.427. So that:

$$Y = \frac{1 + z\lambda}{\lambda} A = 0.427 \times A$$

[20] See Judson and Porter (1996) for various methods of estimating this percentage.

Hence, if we multiply the aggregate asset reduction shown above in Exhibit 4.7 (that includes double-counting) by 0.427 we arrive at the implied credit contraction for non-levered entities. The corresponding figures are shown in Exhibit 4.9; recall that this continues to presume a $250 billion credit loss to the leveraged sector as a whole.

In our baseline scenario of k = 50% and a decline in leverage of 5%, the contraction of credit to end-users is $1 trillion. We can see that our baseline estimate is somewhat insensitive to higher values of k. For instance, a higher recapitalization ratio of k = 75% results in a contraction of $740 billion.

Exhibit 4.9 Decline in Credit ($Trillion) to Non-Levered Entities

		Decline in Leverage		
		0%	**5%**	**10%**
	100%	0.00	0.49	0.98
	75%	0.27	0.74	1.22
k	**50%**	0.53	1.00	1.46
	25%	0.80	1.25	1.70
	0%	1.07	1.51	1.94

Shading indicates baseline scenario.

5. Feedback from Balance Sheet Positions to the Real Economy

We turn finally to considering the link between the balance sheet adjustments by the leveraged intermediaries and the real economy. As is well understood, if the conditions assumed by Modigliani and Miller in their pioneering work on capital structure were true, then there would be no reason for the conditions of intermediary balance sheets to matter for any investment decisions; loosely speaking, in this environment agents make investment decisions based purely on net present value rules, and financing is readily available for any positive net present value projects. But when capital markets are imperfect, then balance sheet positions for firms and individuals can affect their creditworthiness, and access to financing is not assured. Furthermore, if some borrowers are dependent on intermediaries for financing, then any factors that disrupt the supply of financing from intermediaries will have real effects.[21]

There is a large existing body of literature suggesting that both these conditions hold, so that fluctuations in credit availability matter for investment decisions (see Stein (2003) and Hubbard (1998) for surveys). There has been less research tying consumer spending to the availability of intermediated credit, although a large body of literature documents that consumers appear to be liquidity constrained (see Agarwal, Liu and Souleles (2008) for recent evidence). Thus, rather than trying to make a major contribution to these vast literatures, we opt for some very simple evidence that provides some quantitative guidance for the implications of the calculations in the prior exhibit.

[21] See Bernanke and Blinder (1988) and Kashyap and Stein (1994) for further elaboration of these points.

5.1 Correlations between GDP and credit

The first challenge in this exercise is coming up with an empirical counterpart to end-user credit extended by the intermediaries. We use domestic non-financial debt (DNFD) as our proxy; we deflate the series in the Flow of Funds with the GDP deflator to arrive at a constant dollar series. The principal advantage of this series is that it has been widely studied and is familiar to both policymakers and market participants. The main drawback is that this series includes financing that comes from non-leveraged entities. However, deposits in the leveraged sector — our measure H in section 4 — seem to be a key driver of DNFD. Deposits lead DNFD by several quarters, and the (phase-adjusted) year-on-year growth rates are highly correlated.[22] However, H is substantially more volatile than DNFD.

Our summary spending measure is gross domestic product (GDP). Again, we could try to trim out parts of GDP such as government spending that would be sensitive to intermediated credit, but we doubt that would make a difference. Rather we think the transparency of using a standard, known series to establish the correlation is preferred.

As a baseline specification we relate the quarterly log difference of GDP (multiplied by 400 to convert to an annualized rate) to three of its own lags and the lagged four quarter (log) change of DNFD (times 100). We view the lags of GDP as providing the simplest set of controls for the inertia that characterizes the business cycle.[23] We estimate the model starting in 1983 Q1 and use data through 2007 Q4. We choose this starting date because it roughly coincides with the so-called "great moderation" in most macroeconomic aggregates in the U.S. and because the monetary policy regime has been relatively constant over this period.[24] The coefficients and heteroskedasticity-corrected standard errors from this regression are shown in Exhibit 5.1 Last quarter's year-over-year growth in DNFD is positively and significantly correlated with current quarter real GDP growth; so that if DNFD falls by 1 percentage point and stays below baseline for 1 year, quarterly GDP growth would be predicted to fall by 0.13 percentage points initially and by 0.21 percentage points eventually. Thus, our regression specification implies that credit shocks will be spread over successive quarters.

Exhibit 5.1 OLS Regression of GDP Growth on DNFD

Dependent Variable Quarterly GDP Growth (at an annual rate)

Independent Variable	Coefficient	Standard Error	T-Statistic
Constant	1.470	0.475	3.080
GDP Growth$_{t-1}$	0.290	0.112	2.590
GDP Growth$_{t-2}$	0.284	0.102	2.800
GDP Growth$_{t-3}$	-0.224	0.107	-2.100
4 quarter DNFD Growth$_{t-1}$	0.140	0.072	1.950

[22] For example from 1953 to 2007, the correlation between DNFD growth and GDP growth two periods later is 0.66.

[23] Additional lags of GDP growth were not significantly different from zero.

[24] See Stock and Watson (2002) for a survey on the Great Moderation and Cecchetti et al (2007) for a discussion of how this relates to monetary policy.

There is an existing literature dating back to Friedman (1983a,b) showing that DNFD and other credit aggregates have some predictive power for GDP, so the correlation in Exhibit 5.1 is hardly surprising. Given this literature, we do not present many alternative specifications. But the basic findings in the exhibit show up in a variety of other regression specifications, including ones that add more lags of GDP, that use contemporaneous growth in DFND, and that use quarterly growth of DFND. One consistent finding is that if we use data starting in the 1960s, the estimated credit coefficient is much larger, so we view the reported coefficient as being conservative.

While the basic correlation is robust, its interpretation is ambiguous. One reading holds that changes in credit availability cause changes in spending. But it is also possible that the causality runs in the other direction. Specifically, if desired purchases were to unexpectedly increase, it is possible that the financial system would accommodate the increased demand to borrow. Under this view, the fluctuations of the intermediary balance sheets represent the passive accommodation of the fundamental preferences of consumers and firms. Based solely on the evidence in Exhibit 5.1 there is no way to separate these two interpretations.

5.2 Instrumental variables estimation of the credit and GDP relation

To sort out the direction of causality, we must find a proxy that will allow us to separate movements in credit demand from credit supply. One proxy is the TED spread that we discussed in section 2; recall that most of the time this series is relatively constant, but it occasionally widens substantially when bank balance sheets are stressed or when there is a generalized credit event.[25]

Our second proxy comes from Senior Loan Officer's survey on the willingness of banks to make installment loans. This component of the survey is the only one available back to the 1980s. One advantage of this series is that it can move both because credit conditions become noticeably looser or tighter.[26] The possibility that loose credit supply during the 2004 to 2006 period, as opposed to just innovation, was an important driver of the housing boom has been noted by many observers. See Rajan (2008) for a fully articulated description of this mechanism that involves an interaction between low interest rates and intermediary incentives.

Exhibit 5.2 shows the same regression as Exhibit 5.1, except that we use four lags of the TED spread and of the willingness to lend variable as instruments for DNFD. The standard error on the coefficient on credit variable is more than twice the size of the standard error in the OLS specification.

[25] Ideally we would use the LIBOR-OIS spread, since that spread would not reflect developments in the Treasury market. The expected funds rate is not available before 1989. The correlation between this spread and the TED spread (using quarterly data) since that period is 0.86.

[26] A disadvantage is that respondents can be responding to changing business conditions, so that the answer to the question is not purely a measure of supply.

Exhibit 5.2 Instrumental Variable Estimates of GDP Growth and DNFD

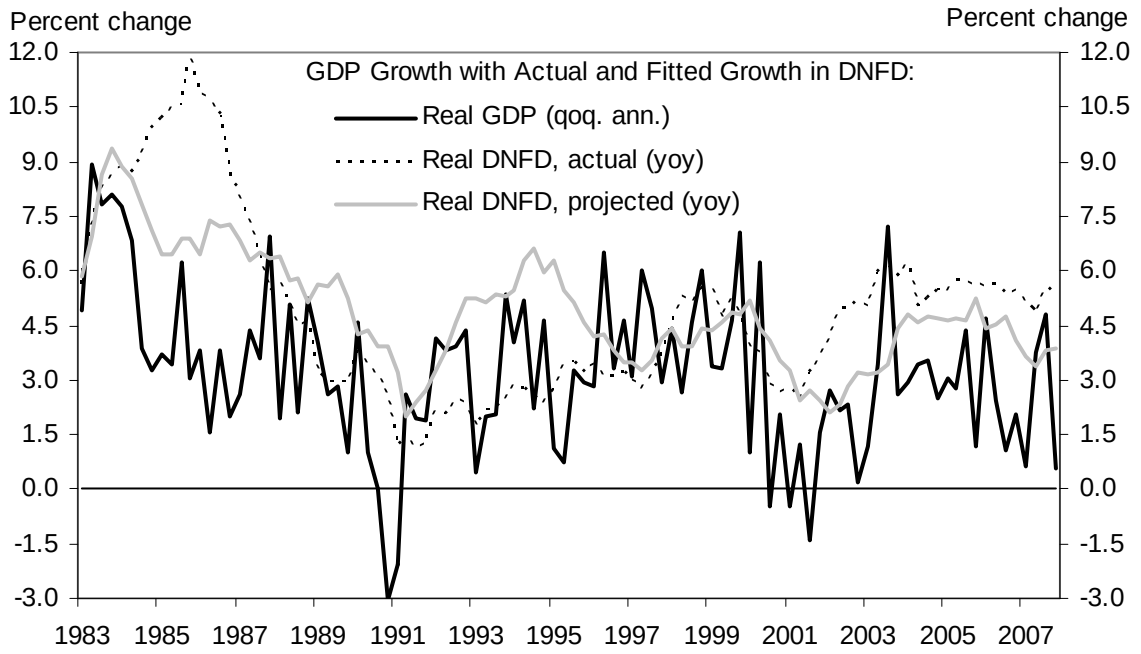
Dependent Variable Quarterly GDP Growth (at an annual rate)

Independent Variable	Coefficient	Standard Error	T-Statistic
Constant	0.904	0.590	1.530
GDP Growth$_{t-1}$	0.247	0.118	2.100
GDP Growth$_{t-2}$	0.242	0.111	2.190
GDP Growth$_{t-3}$	-0.264	0.110	-2.410
4 quarter DNFD Growth$_{t-1}$	0.338	0.176	1.920

Again the credit variable is estimated to have a positive and statistically significant correlation with impact on GDP growth. This was also true in the other instrumental variable estimates that we calculated — for instance, when using only one of the instruments, or using longer samples. Across these various estimates, the coefficient on DNFD was always much larger than the OLS estimate. The estimates in Exhibit 5.2 imply that a 1 percentage point decline in DNFD growth would predict a decline of 0.34 percentage points of GDP growth in the short run and 0.47 percentage points in the long run.

Exhibit 5.3 shows a graph of quarterly GDP growth, along with DNFD and the projected value of DNFD from the first stage of instrumental variables estimation. The figure shows why GDP growth is more strongly correlated with the supply-related variation isolated by the instrumental estimation than with the raw DNFD growth; the projected series tracks much better through the 1980s, especially during the first five years of the sample when raw credit growth was negatively correlated with GDP growth. Thus, the larger estimate in Exhibit 5.2 is not accidental.

Exhibit 5.3 GDP Growth with Actual and Fitted Growth in DNFD



Source: Department of Commerce. Authors' calculation.

As a back of the envelope calculation, we can use the estimate from Exhibit 5.2 along with the potential $1 trillion contraction in end-user credit to calculate a GDP effect from the deleveraging. This contraction is equivalent to a 3.2-percentage-point drop in DNFD growth. The results in Exhibit 5.2 imply that this corresponds to a hit to real GDP growth of 1.5 percentage points over the course of the following year. This impact should be viewed as additive to the impact of housing on real GDP growth via other channels, such as the decline in residential investment and any potential wealth effects tied to falling house prices. We emphasize that the calculation is very rough and should be viewed as quite speculative. But it does suggest that the feedback to the economy from the deleveraging could be substantial.

In our estimate of the impact on GDP, we have taken account only of the contraction of end-user credit to borrowers outside the leveraged sector. However, the diminished activity of the leveraged institutions and other entities involved in the securitization chain may well have an effect on GDP more directly through employment and other real decisions. We have not included such effects here, and so our estimates of the impact on GDP should be seen as being conservative.

5. Conclusions

Taking stock of the recent events, several lessons for central banks emerge. We mention a number of the prominent ones by way of concluding our report.

First, unlike the LTCM crisis of 1998 or the stock market crash of 1987, which bore the hallmarks of crises driven by a collapse of confidence, the current crisis has its roots in the credit losses of leveraged financial intermediaries. Liquidity injections by the central bank are an invitation to the financial intermediaries to *expand* their balance sheets by borrowing from the central bank for on-lending to other parties. However, a leveraged institution suffering a shortage of capital will be unwilling to take up such an invitation. Recognition of this reluctance is the key to understanding the protracted turmoil we have witnessed in the interbank market.

Thus, the rationale for cutting short-term interest rates must rest instead on two other channels. For one thing, lower short-term interest rates will typically result in a steeper yield curve. Over time this improves the profitability of banks and thereby allows them to rebuild scarce equity capital. Moreover, lower interest rates stabilize the real economy by stimulating demand. If stabilizing the real economy improves the positions of borrowers to which the intermediaries are exposed, these cuts can help the intermediaries.

A more effective means to attack directly the financial turmoil would be to facilitate the raising of new equity capital by the banks, and to encourage them to retain cash flow by cutting dividends if necessary. Of course, the cutting of dividends will need to overcome the considerable stigma attached to doing so. On this score, ministers of finance and central bankers may have a role to play in facilitating coordinated action so as to overcome the stigma across regions.

The current crisis has the distinction of being the first "post-securitization" credit crisis, and so it has many unfamiliar features. For this reason, the formulation of a policy response that builds on a clearer recognition of the mechanisms of the crisis is more important than ever. As we have seen, the crisis of 2007–08 has presented a tale of divergence between those markets that suffered acute distress — such as the interbank market and mortgage-related markets, including asset backed commercial paper (ABCP), collateralized debt obligations (CDOs) and jumbo mortgages — and other markets, such as the stock market, which came through the early stages of the crisis largely unscathed. Indeed, it is noteworthy that all the major U.S. stock market indices ended up for the year 2007 and only began falling sharply after concerns took hold that a recession was imminent.

The second lesson to emerge for central banks from recent events is the role of short-term rates in the transmission of monetary policy. Standard macro models presume that short-term rates matter because they signal the central bank's intentions regarding the future course of monetary policy (and hence influence longer-term rates that are held to be relevant for most inter-temporal decisions). But short rates are the prices at which collateralized borrowing and lending are rolled over, and hence determine the marginal

price of quantity adjustments. In the current episode this second function of short-term rates has been critical.

The third, related lesson is the importance of balance sheet quantities as a gauge of financial market liquidity (see also Adrian and Shin (2008)). The balance sheet adjustment mechanism described in our report places emphasis on the amplifying effects of balance sheet changes. The mechanism we have outlined emerges because of the interaction of marking assets to their market prices and the risk-management practices of levered financial institutions. Both these ingredients seem destined to remain a part of financial system for the foreseeable future. Therefore, we would caution against viewing this episode as an outlier that cannot recur. While the intermediaries are particularly exposed to real estate prices, there is no reason to believe that another credit crisis could not emerge if intermediaries suffered losses in another important asset class.

Our empirical results suggest that supply induced changes in credit do affect spending. In gauging the strength of this channel it would be useful to know how much lending capacity is left for the intermediaries. It appears that during the autumn of 2007 many banks were being called upon to provide credit as part of prior loan commitment agreements, which likely delayed their ability to adjust to increasing risk. Ironically, the United States once had a regular monthly survey that tracked how much lending was being done under commitment and how much was truly voluntary. Reinstating that survey seems prudent, and collecting similar information in other advanced economies would also be useful.

Finally, while the importance of tracking quantities on financial intermediaries' balance sheets has some resonance with the traditional monetarist emphasis on the money stock, the analogy is misleading. The securitized markets that have developed over the course of the past decade or so, as well as our balance sheet amplification perspective, make it clear why the traditional monetarist emphasis on the growth of the money stock does a poor job of capturing the fluctuations in market liquidity. Confining attention to deposits alone misses other important and more volatile components on the balance sheets of leveraged financial intermediaries. Central bankers may need to take account of broader balance sheet quantities in the conduct of monetary policy.

Appendix: Two Extensions to Our Credit Loss Estimates

In the main body of the analysis, we restricted our attention to residential mortgages. We estimated that total losses could reach $500 billion, with $250 billion hitting the US leveraged sector. In what follows, we consider two extensions to the analysis in the main text, namely (1) losses on debt other than residential mortgages and (2) the impact of corporate income taxes.

The first extension is to include nonmortgage credit losses. Residential mortgages are the most important single component of the credit deterioration, but the problems are also becoming increasingly visible in other markets. For example, the performance of both commercial real estate (CRE) loans and credit cards is also deteriorating sharply. According to the International Monetary Fund (2008), losses on residential mortgages, CRE, consumer loans, corporate loans, and corporate bonds could total $945 billion, or almost twice as much as our $500 billion estimate of total losses on residential mortgages. (The IMF's residential mortgage credit loss estimate is $565 billion).

The second extension is a consideration of the offset from corporate income taxes. If a firm records a $10 billion write-down on a pretax basis, this overestimates the hit to equity capital because the writedown will eventually reduce the firm's tax liability. Assuming for simplicity that the effective marginal tax rate equals the current statutory rate of 35%, this reduces the hit to equity capital accordingly. However, this assumes that all firms suffering losses are sufficiently profitable to benefit from the corporate income tax reduction. This may be too optimistic, especially if we consider that some of the affected firms are likely to end up going out of business. Hence, it may be safer to assume an offset in the 25–30% range.[27]

On balance, these extensions are likely to raise the estimated hit moderately. The first extension seems likely to almost double overall losses, while the second could reduce the hit by between one-quarter and one-third. Overall, and assuming a proportional modification to losses for the leveraged sector, this could raise the total hit from about $250 billion to around $300 billion.

[27] Under the current net operating loss (NOL) provision of the tax code, firms are able to carry back losses for two years. Legislation is pending in Congress that would extend the period to four years. Still, even if this legislation is enacted, we suspect that some companies will be unable to use the full amount of the loss.

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