NBER WORKING PAPER SERIES

THE FLIGHT FROM MATURITY

Gary B. Gorton
Andrew Metrick
Lei Xie

Working Paper 20027
http://www.nber.org/papers/w20027

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
April 2014

The Flight from Maturity
Gary B. Gorton, Andrew Metrick, and Lei Xie
NBER Working Paper No. 20027
April 2014
JEL No. E32,E42,E44,G01

ABSTRACT

Why did the failure of Lehman Brothers make the financial crisis dramatically worse? The financial crisis was a process of a build-up of risk during the crisis prior to the Lehman failure. Market participants tried to preserve an option or exit by shortening maturities – the "flight from maturity". With increasingly short maturities, lenders created the possibility of fast exit. The failure of Lehman Brothers was the tipping point of this build-up of systemic fragility. We produce a chronology of the crisis which formalizes the dynamics of the crisis. A crisis is a dynamic process in which "tail risk" is endogenous.

Gary B. Gorton
Yale School of Management
135 Prospect Street
P.O. Box 208200
New Haven, CT 06520-8200
and NBER
Gary.Gorton@yale.edu

Andrew Metrick
Yale School of Management
135 Prospect Street
P.O. Box 208200
New Haven, CT 06520
and NBER
metrick@yale.edu

Lei Xie
AQR Capital
2 Greenwich Plaza
Greenwich, CT 06830
lei.xie@aqr.com

> "The Lehman episode was not just a disaster for Lehman. It was a disaster for our country. And like any calamity, it should be subjected to careful, independent scrutiny." Timothy Geithner, written testimony before the House Financial Services Committee, April 20, 2010.

1. Introduction

Why did the failure of Lehman Brothers make the financial crisis dramatically worse? We argue that the financial system became increasingly fragile *during* the crisis, so that even a small shock would have led to a large response *at that point in the crisis*. During the crisis lenders in the money markets sought to shorten the maturities of their loans while borrowing banks sought to lengthen the maturities. Lenders wanted to be able to exit quickly while banks sought to avoid roll risk, which would force them to sell assets at fire sale prices. The desperate maturity struggle between lenders and borrowers manifests itself in the term structures of money market spreads becoming positively sloped, and increasingly so, finally culminating in a sudden massive exit at a sign of trouble – Lehman. We empirically produce a narrative of the crisis that documents the dynamic process of the build-up of fragility during the crisis. We show that a "crisis" is not just a "shock." The run on Lehman was the result of an endogenous buildup of risk.

Our argument, that fragility is endogenous, conflicts with the standard "two shock" view of the recent crisis. In this view, a "crisis" corresponds to a "large shock." As expressed for recent events, the financial crisis of 2007-2008 involved two distinct phases, corresponding to two distinct shocks, the "subprime shock" and the "Lehman shock," e.g. Mishkin (2011). First, there was the period from August 2007 to August 2008 which started with a shock to subprime residential mortgages due to house price declines and a disruption in financial markets, but real GDP continued to rise. Some economists predicted a mild recession.[1] But, in mid-September 2008, the failure of Lehman Brothers caused a much more virulent global financial crisis—"the imminent collapse of the global financial system" (Bernanke, 2009). Thus, the widespread view of the crisis is that it was caused by the disorderly liquidation of Lehman Brothers,

[1] Lucas (2009, p. 67) wrote that, "Until the Lehman failure the recession was pretty typical of the modest downturns of the post-war period . . . After Lehman collapsed and the potential for crisis had become a reality, the situation was completely altered." And, according to Blinder (2009), "everything fell apart after Lehman . . . After Lehman went over the cliff, no financial institution seemed safe. So lending froze, and the economy sank like a stone. It was a colossal error, and many people said so at the time" (Blinder 2009).

the view that informs the Dodd-Frank legislation. Some economists attributed this to policy failure: the Fed should not have let Lehman fail.[2]

In this paper, we argue that this two shock view of the crisis is not accurate. Rather, the crisis was an ongoing build-up of fragility as the maturities of money market instruments shortened, starting around August 2007 and continuing, finally resulting in the Lehman failure, in effect caused by this build-up of fragility. In order for Lehman to fail suddenly, enough creditors had to be in the position to not renew their loans, i.e., a very large amount of Lehman financing had to be in the form of, say, overnight sale and repurchase agreements ("repo").[3] The shock to subprime starts things off—the economy becomes anxious-- and then the situation evolves into a crisis. The build-up of fragility was protracted, involving spreads increasing, maturities shortening, and repo haircuts increasing.[4] Finally, this buildup culminates in the run on Lehman. Thus, a crisis is a dynamic process in which the effect of a "shock" is essentially endogenous.[5]

Understanding the dynamics of the crisis requires determining the timing of important events. To set ideas we provide a small model of the money market which shows the timing of events: spreads rise, maturities shorten, the term structure of spreads increases, and lastly lenders exit by not rolling over their loans (i.e., haircuts rise, possibly to 100%). In the model loans are collateralized, as in repo. Lenders want to lend short when a shock has occurred, and banks want to borrow long. Banks offer a higher spread for longer loans and a lower spread for shorter loans. The economy can become fragile when lenders lend a sufficient amount short so as to be able to force the bank into bankruptcy early if there is a need to exit.

We document the model chronology, by showing that it matches an empirical chronology of the crisis. The empirical chronology is based on locating the dates of structural breaks in panel data sets, based on

---

[2] For example, Taylor (2009) and Meltzer (2009) have articulated this view.

[3] "Repo" is short for sale and repurchase agreement. Under a repo contract the lender deposits (i.e., lends) money to the borrower (the bank) for a short period of time at interest and receives bonds as collateral to ensure the safety of the deposit. The collateral is marked-to-market. The return on the bonds used as collateral accrues to the borrowing bank. Repo was central to the crisis; see Gorton (2010), and Gorton and Metrick (2012).

[4] Suppose a bank which wants to finance assets worth V with repo debt (D) and equity (E), so V=D+E. A haircut is defined as follows: $H \stackrel{\text{def}}{\equiv} 1 - \frac{D}{V}$ which implies that the amount lent to the bank by the lender, where the collateral is V, is D=V(1-H). Substituting this into the balance sheet identity (V=D+E) shows that E=HV, which is the amount of equity that the bank would have to raise to back the assets. If the haircut is zero, then with respect to these assets, the entire amount can be repo-financed, for example.

[5] This is the viewpoint of Gorton and Ordoñez (2014) who show that a credit boom can result in a crisis due to a "small shock", one that would not have caused a crisis had there been no credit boom.

the methodology of Bai (2010). Our chronology dates the first structural break in panels of spreads on subprime-related instruments, secured money market instruments (repo), unsecured money market instruments, credit derivative (CDS) measures of the risk in financial firms, and price-based measures of real economic activity.

The chronology of the crisis is also very important because it allows us to formalize the notion of a financial crisis. What is a "crisis"? A financial crisis can be defined as a common breakpoint in the characteristics (e.g., spreads, maturities) of different forms of bank-produced money (i.e., repo and asset-backed commercial paper (ABCP)).[6] In a crisis short-term bank debt becomes suspect and banks are unable to satisfy demands for cash. This causes the breakpoints. But, individual crisis episodes have unique features and it has been difficult to empirically formalize the general notion of a crisis to date. For example, Boyd, De Nicolò, and Loukoianova (2011), examining a cross country panel of modern financial crises, point out that it has been difficult to date the start of crises, or even to determine whether there has been a crisis in some cases. Existing data sets of international crises, based on annual data, do not agree on start dates or on crisis episodes. We use daily data and seek to formalize the crisis dating for the events of 2007-2008 and, in the process, understand crises.

We date the subprime shock and the resulting financial crisis, coming some months later. The crisis was first located in the money markets, and emanated outwards ultimately to the real economy. We show that the repo market was the first money market to be disrupted, followed by the unsecured money markets, in particular the asset-backed commercial paper market (ABCP). But, this was only the beginning. We also trace subsequent breakpoints, in spreads, in the term structures of spreads, haircuts, the risk of financial firms, and so on, to determine the dynamics of the crisis.

Once a (perhaps small) shock has occurred, the dynamics of the crisis depend upon the response of market participants. Initially, spreads on money market instruments rise, as shown in Figure 1. The figure shows (annualized) spreads (relative to the overnight index swap rate) on overnight loans. The figure shows spreads for federal funds, general collateral repo (GC), four categories of commercial paper, and six categories of repo, differentiated by the nature of the collateral.[7]

[6] Asset-backed commercial paper (ABCP)is commercial paper that is issued by conduits, which is a special purpose vehicle (a legal entity) that buys asset-backed securities, financing this by issuing commercial paper. See Covitz, Liang, and Suarez (2009) and Acharya, Schnabl and Suarez (2011).

[7] General collateral (GC) repo is repo where the underlying collateral is U.S. Treasury debt. The overnight index swap rate is a fixed-to-floating interest rate that ties the floating leg of the contract to a daily overnight reference

As shown in Figure 1, low spreads on money market instruments is consistent with money markets being integrated via arbitrage. Although the money markets have different clienteles, some large U.S. banks can trade in federal funds, LIBOR, commercial paper, and sale and repurchase (repo) markets to keep the rates in line. Market participants determine the acceptable maturities of money market instruments so that they are indifferent.

During the crisis this changes, as shown in Figure 1. If there is a desire by borrowers to borrow at longer maturities and a desire by lenders to lend at shorter maturities then the term structure of spreads will become upward sloping (as shown in the model). The "spread" refers to the particular money market (annualized) rate minus the "riskless" rate for a given maturity. The "term structure of spreads" refers to such spreads at different maturities. An increase in the term structure of spreads reflects the differing concerns of borrowers and lenders. Banks want to lock-in funding and so they offer to pay a higher rate for longer maturity borrowing, and a lower rate for shorter maturities. But, lenders are only willing to lend short, keeping open their exit option. In other words, lenders care about shortening the maturity – the flight from maturity-- when they are concerned about being in a position to get their cash at very short notice. An upward sloping term structure of spreads is an indication of these concerns on the parts of borrowers and lenders. During the financial crisis spreads widen and the term structures of spreads steepen dramatically. The steepening of the term structures of spreads indicates an increase in fragility as lenders position themselves to demand cash at very short notice.

Fragility builds up as maturities shorten. We document the build-up of fragility by showing that the maturities of money market instruments shortened starting in July 2007. However, only in the case of commercial paper (CP) is daily issuance data available that can be used to directly examine maturity. The maturity of CP declined during the crisis even though the average quality of the issuers was improving because lower quality borrowers were forced out of the market. This is shown in Figure 2, which graphs the ratio of 20 days and under maturities to over 20 days for ABCP issuance rated AA. The figure shows the decline in maturity starting in August 2007, even for the issuers that remain in the market. Due to a lack of issuance data for other money market instruments, we focus on a prediction of the model that the term structures of money market spreads rise during the crisis. During normal times the spreads are all very low and the term structure of spreads is flat, corresponding to money market instruments being near-riskless. During the crisis the term structure becomes increasingly positively

---

rate. The reference rate is often the Federal funds rate. The floating rate is equal to the geometric average of the overnight reference rate.

sloped, reflecting the desire of lenders to lend short and the desires of the borrowers to borrow long. Figure 3 shows the term structure of spreads of LIBOR loans at three dates (corresponding to the break points we find). The increasingly positive tilt of the term structure of spreads is apparent.

We find that repo spreads, the term structure of spreads and repo haircuts all show *second* breakpoints *before* Lehman. This is the buildup of risk. Finally, the build-up reaches a finale when lenders exit from Lehman—the run.

As maturities shortened, the economy faced a hair trigger—the exit option in the model-- in which a small shock could cause a large sudden exit from the money markets. This occurs at the date of the Lehman Brothers failure. Note that our argument makes no assumption about whether Lehman's failure was a small or large event in terms of the information conveyed to market participants. Rather, we are arguing that market participants by shortening maturities were in a position to massively react. This is the key tipping point, and it is endogenously created.

The paper proceeds as follows. In Section 2 we outline the model and the results. In Section 3 we review the design of money market instruments and present the data that we will use. In Section 4 we analyze the spreads on money market instruments before and during the crisis. The chronology of the financial crisis with respect to spreads is produced and analyzed in Section 5. We then go on to examine other data panels and find their breakpoints. We determine the date of the subprime shock, the date of the run on repo and the subsequent runs on unsecured instruments. We also date the start of the real effects of the crisis. We also date later breaks. In Section 6 we document the build-up in fragility during the crisis, that is, the maturity shortening. Commercial paper issuance was at reduced maturities. And we examine the term structure of spreads in the money markets. Section 7 provides the overall chronology of the crisis and an associated discussion. Section 8 concludes.

2. A Model of the Money Market

In this section we present a very simplified model that illustrates some propositions that will be the focus of attention in the empirical work. The main point is the endogenous creation of fragility via a buildup of a sufficient amount of short-term lending that can cause banks to potentially face runs. The conflict between lenders wanting to lend short and borrowers wanting to borrow long has noted before by other authors. In Stein (2012) banks have an incentive to issue long debt because they believe that they can avoid being forced to sell assets at an interim date if lenders do not renew their short loans.

Stein's focus is on possible "excessive" creation of short-term debt and the resulting fire sales. In Diamond (1991) borrowers who privately expect their credit rating to improve have an incentive to issue short-term debt. But doing so exposes them to early liquidation.[8]

In subsection A we present the model. Then in subsection B we further interpret the model further to inform the empirical work. We layout the dynamic phases of the overall crisis.

A. A Simple Model of Repo

We examine a world of risk neutral borrowing banks and lenders (or "depositors"), where each period the borrowing bank must renew its financing using one- or two-period collateralized debt (repo). There are two possible states of the world: Normal (N) and Anxious (A).[9] The transition probabilities are given by:

	$\mathbf{A_{t+1}}$	$\mathbf{N_{t+1}}$
$\mathbf{A_t}$	p_{AA}	p_{AN}
$\mathbf{N_t}$	p_{NA}	p_{NN}

where $p_{AA}+p_{AN}=1$ and $p_{NA}+p_{NN}=1$. We also assume that $1\approx p_{NN}>p_{AN}>p_{AA}$ and that $p_{NA}\approx 0$. The probability of the Anxious state occurring is very low (a rare event), hence the economy is usually in the Normal state. If it does occur, we say the economy is in a Crisis.

In the Normal state, the per dollar value of assets is \$1. In a Crisis, the per dollar price of assets is ϕ_t at date t. If the path of states is ever AAA (i.e., three Anxious states in a row), then the bank is (exogenously) insolvent and the economy is in a Depression.[10] If the Anxious state path is AA then at date t+1 $E[\phi_{t+1}|AA]<\phi_t$, i.e. fundamentals are deteriorating. We will call this state bank Runs. See Figure 4. The runs here will be endogenous.

The (representative) bank has assets, L, which at the end of a period are worth RL so long as the bank is solvent. The bank's assets are financed by one- and two-period collateralized loans (repo), where L is used as collateral. In what follows, $X_{t,\tau}$ refers to the value of the variable contracted for at date t for τ periods (i.e. a τ maturity). At each date t the bank's loan portfolio, L, must be financed by one- and two-period repo:

[8] In Brunnermeier and Oehmke (2013) borrowers also may have an incentive to rely excessively on short-term financing because this dilutes other creditors.
[9] We have borrowed the term "anxious" from Fostel and Geanakoplos (2008).
[10] We recognize the irony of calling this path AAA.

$$L = D_{t,1} + D_{t,2} + D_{t-1,2} \qquad (1)$$

where $D_{t,1}$ and $D_{t,2}$ are chosen now, at date t, and $D_{t-1,2}$ was chosen last period, t-1. In the Crisis state of the world the bank cannot raise external funds by issuing equity or other non-repo debt. But, the bank can raise cash in the amount of Γ via asset sales if need be, but it would prefer not to do this.

At date t, the amount the bank owes lenders is: $R_{t-1,1}D_{t-1,1} + R_{t-2,2}D_{t-2,2}$. At date t the bank must pay off the one-period loans from last period as well as the two-period maturity loans made at date t-2. The bank seeks to pay the interest owed and "roll" the amount $\Delta_t \equiv D_{t-1,1} + D_{t-2,2}$ with new one- and two-period loans. Notice that if:

$$\Delta_t - \left[D_{t,1} + D_{t,2}\right] > \Gamma \qquad (2)$$

at any date t, then the bank is insolvent if an insufficient amount is rolled and lenders ask for cash back. From (2) there is a critical minimum amount of one-period loans, $D_{t,1}$, such that lenders would cause the bank to be insolvent at date t+1 since the bank could no pay enough cash out to the lenders. This could lead to a Run at date t+1 if:

$$D_{t,1} > \Gamma - \Delta_t \equiv \widehat{D}_{t,1}. \qquad (3)$$

When $D_{t,1} > \widehat{D}_{t,1}$, we say that the bank is vulnerable to a run on repo. Normally, lenders would just renew their loans without ever receiving cash. This is what it means to "roll" the loan. So, to emphasize, (3) could hold, but there would be no problem if enough lenders rolled their loans, rather than asking for cash and then relending the cash or not renewing the loans.

The bank does not know the fraction of lenders that will want cash, rather than roll their loans. Prior to entering the Crisis, banks made a risk management choice about how much of this liquidity risk to bear. Bank risk management chooses a parameter $\gamma \leq 1$ so that the constraint is $D_{t,1} < \gamma\widehat{D}_{t,1}$, that is there is a bound how much one period repo the bank can use. If condition (3) is satisfied and all (or more than γ of the) lenders go to the bank and ask for their cash then the bank is insolvent.[11] This possibility of a run

[11] Because the bank has only Γ available, a sequential service constraint could generate a run, as in Diamond and Dybvig (1983) or these multiple equilibria could be eliminated as in Goldstein and Pauzner (2005). For simplicity we follow Diamond and Dybvig.

is not taken into account by the lenders, as in Diamond and Dybvig (1983).[12] Or, the positive probability of a run is "neglected," as in Gennaioli, Shleifer and Vishny (2012).[13]

If there is a run and the bank is insolvent, then the lenders take possession of the collateral, which in the Anxious state at time t+1 has a value of:

$$\phi_{t+1}[D_{t,1} + D_{t-1,2} + D_{t,2}] \equiv \Sigma_{t+1}. \qquad (3)$$

In particular, this includes the collateral backing $D_{t,2}$ which is also recovered even though this loan matures at date t+2.[14]

We will imagine that the economy has just arrived in state A, a "shock", and is in Crisis. This is *not* a a full blown Run but may induce a Run subsequently, which will be endogenous if (2) becomes satisfied and if lenders ask for their cash next period. The representative lender is unaware that he is representative; he takes prices as given and chooses one- and two-period loans that he is willing to make. He is unaware of the total amount of one-period loans. Unbeknownst to him, it can happen that $D_{t,1} > \widehat{D}_{t,1}$. We will focus on the case where this does occur. In this case, there can be a "run on repo" if the lenders have any reason to believe that the bank's liquid assets are insufficient to repay the loans.

The bank, recognizing the possibility of a run, would prefer at date t that only, or a sufficient amount, of two-period loans be made at that date so as to avoid the possibility of being liquidated at date t+1 if the the economy gores to Run. The bank does not know what fraction of lenders will ask for their cash, possibly none. The bank has already chosen γ. We assume that γ is chosen by the risk manager and is exogenous to the model.[15] In choosing γ the bank would like to avoid the event of a fraction of lenders exiting at date t+1, since there is a chance that at date t+2 the state is N.

So, at any date t there is one of four outcomes:

- Roll the repo; this always occurs when the state is N;
- Roll, but such that the bank is vulnerable because $D_{t,1} > \widehat{D}_{t,1}$;
- The bank is vulnerable and there is a run on repo in state AA;

[12] There are well-known problems with this (e.g., see Postlewaite and Vives (1987)), but we do not pursue these issues here. Also, see Morris and Shin (2012).
[13] This is assumed to simplify the model for the purposes of exposition.
[14] This is, indeed, how repo contracts work. Either party can unilaterally terminate the contract upon the other party's insolvency.
[15] Perhaps it is set by a regulator.

- The bank is exogenously insolvent, if the path of states is AAA; the economy is in Depression.

In state N $R_{t,2} = R_{t,1}$ because $p_{NN} \approx 1$, i.e., the term structure is flat in the Normal state, as we saw in Figure 3. But upon entering state A, we have:

Proposition 1 (Upward tilt in the term structure of repo rates in a Crisis): In state A, repo rates are upward sloping, $R_{t,2} > R_{t,1}$ in equilibrium.

This is shown in the Appendix A. Given its risk preferences, γ , the bank must attract lenders to the two-period loan, so the bank sets the term structure to be upward sloping, providing an incentive to lend for two periods and a disincentive to lend for one period. Lenders also want an upward sloping term structure because the risk of loss at date t+2 is greater than at date t+1. See Figure 3.

Proposition 2 (Run on Repo): In state A, if, in aggregate, $D_{t,1} > \widehat{D}_{t,1}$ at date t, then there can be a run on repo at date t+1.

Proposition 2 is obvious by construction and the assumption of sequential service (as in Diamond and Dybvig (1983)). The model is simple enough to display the properties highlighted in the above two propositions, which encapsulate the basic dynamics we will examine in the data.

B. Interpreting the Model

Figure 4 shows the paths of the model that we will be interested in. We want to be clear about the dynamics of the crisis and assign names to certain phases. This is important for the empirical work. In the figure the economy is in the Normal state until the first node labeled "A." At this node the representative agent is Anxious; the economy is in a Crisis. The economy could still recover, but still in a Crisis agents take actions to protect themselves should things get worse. They shorten maturities, in particular. If the economy does not recover, another A state is realized, then there are Runs (corresponding to Lehman). This is the panic. Even with bank runs the economy could still recover (perhaps because of government intervention), but if not, then the economy goes into a Depression or Great Recession.

The sequence Crisis-Runs-Depression is clearly the worst outcome. Our point will be that these are fairly distinct phases. We think of the "Runs" phase as corresponding to the Lehman failure. This is preceded by the endogenous build-up of fragility during the Crisis phase. We discuss this further in the Conclusion after the empirical results are presented.

Reality of course is more complicated than the model. For one thing, the process can be prolonged, in which the term structure moves up in several steps and haircuts increase in steps. For simplicity we did not include haircuts in the model, and haircuts can rise in steps before the Run phase.[16]

3. The Money Markets

Money market instruments include U.S. Treasury bills and privately-produced instruments. Privately-produced money market instruments are short-term debt instruments that are liabilities of financial intermediaries. These were at the heart of the financial crisis, in particular asset-backed commercial paper (ABCP) and sale and repurchase agreements (repo). Money market instruments serve as short-term stores of value for financial and nonfinancial firms, and for investors, like pension funds, institutional money managers, hedge funds, and money market funds. Money market instruments are not insured, but otherwise resemble demand deposits in important ways. In particular, they offer a fairly safe store of value and easy access to the cash because of their short maturities. In this section we briefly review the relevant money market instruments and introduce the data that we will subsequently analyze.[17]

A. Description of the Instruments

Privately-produced money market instruments are designed to be as close to riskless as privately possible, so that they can function as money, as described below. Money market instruments are not insured by the government. They are, however, structured to be safe. They often have maturities of overnight or a few days, weeks, or sometimes months and they are either secured by collateral or can only be issued by high-quality borrowers.

Privately-produced money market instruments include secured instruments, namely sale and repurchase agreements ("repo") which are backed by explicit collateral and unsecured instruments that are backed by the issuer's portfolio of assets, usually in the form of a portfolio of bonds of a financial firm or of a managed special purpose vehicle. There may be overcollateralization in the form of a haircut.[18]

---

[16] A previous version of the paper included haircuts and richer dynamics but the simpler version is sufficient to make our points.

[17] We omit consideration of bankers' acceptances and wholesale certificates of deposit because we do not have daily data on their rates.

[18] See footnote 4.

Repo involves providing specific collateral to depositors who are lending money. The collateral might be government bonds or privately-created "high quality" bonds, such as asset-backed securities. Depositors must agree with borrowers on the type of collateral and its market value, and then depositors/lenders take possession of the collateral.[19] If the counterparty fails, then the non-defaulting party can unilaterally terminate the transaction and sell the collateral (or keep the cash). This is because in the U.S. repo is carved out of the bankruptcy process. This facilitates its use as money.

Unsecured money issuers are screened; they must be high-quality so the backing assets are viewed as near riskless. Commercial paper (CP) issuers are screened by investors and rating agencies. Only high quality financial and nonfinancial firms can issue CP. CP does not have explicit insurance or specific collateral, but access to the CP market is reserved for low-risk issuers with strong credit ratings. And CP is also backed up by a bank line of credit (see, e.g., Moody's (2003), Nayar and Rozeff (1994)). Hence CP issuers have very low default risk. CP issuers are high quality, and if they deteriorate there is "orderly exit." When a firm's credit quality drops, perhaps as indicated by its rating, it cannot issue new CP because investors will not buy it. The firm may instead draw on its bank line to pay off its maturing CP. This process of "orderly exit" from the commercial paper market maintains the high quality of the issuers. Because of the possibility of exit occurring firms must maintain back-up lines of credit.[20]

Asset-backed commercial paper (ABCP) conduits are a special type of CP issuer. Such a conduit is a special purpose vehicle (a legal entity) that buys asset-backed securities, financing this by issuing commercial paper. See Covitz, Liang, and Suarez (2009) and Acharya, Schnabl and Suarez (2011). The activities of ABCP conduits are circumscribed by their governing documents, and they are required to obtain high ratings. One important feature of asset-backed commercial paper is that the conduits must have back-up liquidity facilities in case they cannot renew issuance of their commercial paper. These liquidity facilities cover the inability of the conduits to roll CP for any reason. In most cases these facilities are sized to cover 100 percent of the face amount of outstanding CP. They are typically provided by banks rated at least as high as the rating of the CP. See Fitch (August 23, 2007). Such a

[19] The collateral is valued at market prices. During the period of the repo, there may be margin required to maintain the value of the collateral exactly.

[20] "Orderly exit" is discussed by Fons and Kimball (1991) and Crabbe and Post (1994). The back-up lines were introduced after the Penn Central failure led to a crisis in the CP market; see Calomiris (1989, 1994) and Calomiris, Himmelberg and Wachtel (1995).

liquidity agreement is usable immediately if the commercial paper cannot be remarketed (rolled).[21] If a conduit draws on its liquidity facility, the provider of the liquidity facility, usually the sponsoring bank, purchases bonds from the conduit or loans money to the conduit to purchase commercial paper in the case that the commercial paper cannot be issued.

We also examine the two largest interbank money markets, the London interbank market (the "Euro-dollar" or "LIBOR" market) and the U.S. federal funds market. In the LIBOR market banks deposit excess U.S. dollars with other banks, sometimes referred to as "Eurodollar deposits," and earn interest at the London interbank offered rate (LIBOR).[22] The Eurodollar or LIBOR market involves large global banks, which are monitored by their domestic bank regulators. The LIBOR and federal funds markets are unsecured, but both rely on screening and monitoring by bank regulators.

Each money market has different clienteles. Regulated banks are the participants in the LIBOR and federal funds market. Only U.S. commercial banks can participate in the federal funds market. The repo banks are the financial institutions that can borrow in the repo market, a larger group than commercial banks, including most notably the old U.S. investment banks and large foreign banks. Non-financial firms and non-bank financial firms can issue commercial paper.[23] However, these four major money markets are connected. While not all financial institutions have access to all four markets, as mentioned above, the largest U.S. banks are active as borrowers and lenders in all four markets. Because these banks would eliminate arbitrage opportunities across these markets, we would expect that all four money markets would display the same near-money-like riskless qualities; their spreads should normally be "low," and the term structure of spreads should be flat. Indeed, see Figure 1. In Section 4 we further examine the proposition that money markets are near riskless.

The secured and unsecured markets behave differently (as we will show subsequently). On the one hand, repo involves specific collateral as opposed to the general credit of a firm or a conduit, whose

[21] There are no material adverse change (MAC) clauses in ABCP liquidity facilities. A MAC is a contract provision that specifies contingencies under which the contract is null and void. See Moody's Update (Prepared Remarks Sept. 12, 2007).

[22] LIBOR interest rates are based on a survey by the British Bankers' Association. The rate is the simple average of the surveyed bank rates excluding the highest and lowest quartile rates. The rates are announced by the BBA at around 11.00 am London time every business day. Such rates are estimated for maturities of overnight to up to 12 months and for 10 major currencies. The Intercontinental Exchange (ICE) took over the administration of LIBOR on February 1, 2014.
See http://www.bba.org.uk/bba/jsp/polopoly.jsp;jsessionid=aAEWKNo02dUf?d=103 .

[23] CP issuance by nonfinancial firms is small as shown below.

asset portfolios may be high quality but which are harder to monitor. On the other hand, a depositor in the repo market may accept lower quality privately-issued bonds as collateral.

B. Data

We analyze the following money market instrument categories: federal funds; LIBOR (Eurodollars); general collateral repo (GC); four categories of commercial paper: A2/P2 nonfinancial, A1/P1 asset-backed commercial paper, A1/P1 financial, and A1/P1 nonfinancial;[24] and six categories of repo, which differ by the type of privately-produced collateral used as backing: AAA/Aaa-AA/Aa asset-backed securities (ABS), including residential mortgage-backed (RMBS) and commercial mortgage-backed securities (CMBS), RMBS and CMBS with ratings between AA and AAA ,AAA/Aaa-A/A auto loan-backed, credit card receivables-backed and student loan-backed ABS, AAA/Aaa-AA/Aa collateralized loan obligations (CLOs), AAA/Aaa-AA/Aa corporate bonds, and A/A-Baa/BBB+ corporate bonds. In addition, we use a number of other series to capture the state of the real economy, the state of the subprime market, and the state of the dealer banks (the old investment banks).

All the data series we will use are listed in Table 1.[25] The first four rows are series that describe the real sector of the economy: the VIX index, the S&P 500 index return, the JP Morgan high yield index, and the Dow Jones investment grade index of credit default swaps. The next two rows are measures of subprime risk: two tranches of the ABX index, an index linked to subprime securitizations, and home equity loan securitizations.[26] "Financial CDS" refers to an equally-weighted index of the 5-year credit default swaps (CDS) on U.S. financial institutions, including some commercial banks and dealer banks.[27] We also use the individual banks' CDS prices. Then there are thirteen money market instruments, including four categories of commercial paper, fed funds, LIBOR, and the rates on seven categories of repo, including general collateral repo (GC).

---

[24] Commercial paper ratings are as follows: "Superior" CP is rated P1 by Moody's, A1+ or A1 by S&P, and F1+ or F1 by Fitch; The next category, "satisfactory," is rated P2 by Moody's, A2 by S&P, and F2 by Fitch.

[25] We also looked at spreads on thirteen categories of non-mortgage asset-backed securities and also CDS for thirteen European banks. We mention these results in passing later.

[26] Because of clientele effects, different tranches of the ABX index did not always move together. The ABX index is a product of Markit; see http://www.markit.com/en/products/data/indices/structured-finance-indices/abx/abx.page . Background on the ABX can be found in Fender and Scheicher (2008).

[27] A "broker-dealer" or "dealer" bank refers to a financial intermediary which is licensed the Securities and Exchange Commission to underwrite and trade securities on behalf of customers. Broker-dealers are regulated under the U.S. Securities and Exchange Act of 1934.

We analyze spreads, where the spread is the promised contractual rate minus the federal funds target rate. All spreads are annualized. There is noise in the actual (effective) federal funds rate, as it deviates from the target, resulting in Fed action. This deviation worsens during the crisis. For the spread calculation, other candidates are the Treasury bill rate or the overnight index swap rate (OIS) rate. Treasury rates are affected during the crisis due to a flight to quality, but results are not significantly different if we use the OIS rate instead of the target federal funds rate.

4. Money Market Instruments Before and During the Crisis

To what extent are the different money market instruments "money"? A simple way to look at this is to examine the spreads on money market instruments. Intuitively, money market instrument spreads should be low. But, they need not be the same if the degree of "moneyness" differs to some extent.

In examining spreads one issue that we must contend with is the presence of "seasonal effects" noted by previous researchers in some money market instruments and in commercial bank balance sheets. Allen and Saunders (1992) found window dressing behavior by banks. In particular, they found that money market instruments were the important liabilities facilitating temporary upward movements in total assets. Kotomin and Winters (2006) found associated spikes in federal funds rates and federal fund rate standard deviations. Also, see Griffiths and Winters (2005) and Musto (1997).

In this paper we are not focusing on these seasonal effects.[28] In Appendix B we examine money market spreads during normal times with regressions that include calendar dummies for "seasonals," that is quarter-end dummies, first, 15th and last day of month dummies, and Monday and Friday dummies. Appendix B Table B1 presents regression results of money market spreads on different calendar dummies.[29] The results in Table B1 show that "seasonals" are very important in the money markets. Spreads increase quite significantly at various calendar dates.

Table 2 presents the intercepts from the regressions of the spreads on the calendar dummies, for different subsamples: prior to the crisis, during the crisis, and for three different stages of the crisis (corresponding to subsequently estimated breakpoints in the series). Table 2 allows us to see the

[28] This is an area for future research.

[29] The appendix does not present all the regressions behind the results in Table 2 for the sake of space. Only the results for the period prior to the crisis are presented.

relative ability of the private sector to produce "money." (Figure 1 shows these deseasonalized spreads before and during the crisis.)

Focusing first on the period prior to the crisis, the following is clear. All spreads are less than 11 bps. Also, note that the spreads on GC repo, A1/P1 financial CP, A1/P1 nonfinancial CP, and repo backed by the highest rated corporate bonds are significantly negative, that is they are below the target federal funds rate. Federal funds are unsecured, but banks are overseen by the Fed. GC repo is collateralized by U.S. Treasuries, so it is better collateral than federal funds, which is backed by a bank's portfolio. And, banks are examined, that is, screened. By screening issuers, the spreads on the highest quality CP are negative. Similarly, repo backed by the highest quality corporate bonds shows negative spreads.

Relative to federal funds, it is hard for the private sector to replicate the moneyness of the best instruments. The other money market instruments are of lower quality in that the collateral is of lower quality or the issuers are of lower quality. Spreads on these categories are all positive, relative to the federal funds target rate. Finally, note that LIBOR is significantly higher than federal funds. Perhaps global banks are not screened as well as U.S. banks.

The categories with the highest spreads are repo backed by asset-backed securities with lower ratings and A2/P2 nonfinancial commercial paper. A2/P2 is the lowest (worst) rating for commercial paper and it had an average spread of 8.97 basis points. Also, repo which uses asset-backed securities (ABS), residential mortgage-backed securities (RMBS), or commercial mortgage-backed securities (CMBS), which have a rating below AA, had an average spread of 10.16 basis points.[30] After these two categories comes LIBOR with a spread of 5.33 basis points. Prior to the crisis LIBOR was widely believed to correspond to AA risk. Next is repo with the same collateral, but rated AA or higher, at 5.16 basis points, and collateralized loan obligations rated AA or higher which has the same spread.

The spreads intuitively correspond to the quality of the money. There are clearly degrees of "moneyness" reflected in the spreads. It is apparent that not all privately-created money is the same. We do not know how much money of each category was being used before or during the crisis, but in

[30] The largest nonmortgage asset types in ABS are student loans, car loans, and credit card receivables. Subsequently, we use ABS to indicate all types of securitizations. See Gorton and Metrick (2011) for details about securitization.

order for there to be spread data, there must have been some significant amount.[31] The picture that emerges is one in which the private sector creates money of different qualities, that is, some types of money have spreads which include a risk premium.[32]

What happened to the money markets in the crisis? We take as the crisis period the period following the first breakpoint in repo (discussed below). This is the column called "During the Crisis" in Table 2.[33] Note that money market instruments that are "high quality" show *reduced* spreads. These include federal funds, general collateral repo, and A1/P1 commercial paper, both financial and nonfinancial.[34] This is the flight to quality, where some instruments are perceived as better money. But, all the other money market instruments' spreads show very large increases. Figure 1 displays the spreads (intercepts) before and during the crisis.

The other instruments, all privately-produced, show large spikes in their spreads; see Figure 1. For example, repo backed by residential mortgage-backed securities or commercial mortgage-backed securities, rated lower than AA, increase from 10.16 to an average of 98.59 basis points during the crisis. A1/P1 asset-backed CP rises from an average of 1.5 basis points in normal times to 40.28 basis points during the crisis.

In Table 2 it is clear that during the crisis it became harder for the Federal Reserve System to keep the fed funds rate close to the target. (The spread for fed funds is the average difference between the effective fed funds rate and the target rate.) Before the crisis the spread is less than half a basis point, at 0.32 basis points, very close. But, in contrast, during the crisis this spread rises to 8.06 basis points. And, in particular, during the period labeled "Crisis: Lehman," it reaches a high of an average of 37 basis points. This is consistent with the results of Bech, Klee, and Stebunovs (2012) who show that the relation between the GC repo rate and the federal funds rate weakens during the crisis (in an error-correction model).

The table also shows the results for subperiods corresponding to the other breakpoints. The subperiods are (1) Pre-Crisis: prior to the crisis onset (the first breakpoint in repo discussed below, which is July 23,

[31] This statement comes from the traders who provided the data.
[32] This is similar to the Free Banking Era when private bank notes traded at different discounts at distant locations. See, e.g., Gorton (1999, 1996).
[33] As before, the table shows spreads calculated with regressions including the calendar dummies, like the previous results in Appendix Table B1. To save space though these results are not included.
[34] The spread for fed funds is the average difference between the effective fed funds rate and the target rate.

2007). During the crisis, there are three subperiods: (2) Pre-Lehman: the crisis from the onset to Lehman (the second breakpoint in repo discussed below); (3) Lehman: the aftermath of Lehman until December 2008; and (4) After December 2008. The middle period of the crisis, which brackets the failure of Lehman Brothers, was the height of the crisis in terms of spreads. After December 2008, spreads are lower than in the Lehman period, except for all categories of repo using asset-backed securities as collateral. The spreads on repo backed by ABS just kept rising. ABS (including RMBS and CMBS) becomes "information-sensitive" (in the nomenclature of Dang, Gorton and Holmström (2011)) and can't be used as collateral. See Gorton and Metrick (2012).

Figure 5 conveys a sense of what happened in the crisis. Figure 5 shows the spreads adjusted for the seasonal effects. The two vertical lines in the figure correspond to two of the breaks in the set of repo spreads (that we discuss shortly). Before the first break in repo, early in 2007, the spreads are tightly bunched, with the occasional uptick. There are two crisis regimes visible: the Crisis and Run phases. The first occurs around August 2007 and last until the second repo break. The second starts with the Lehman bankruptcy. As we saw before, in Table 2, not all spreads widen. Spreads *diverge* as some instruments lose their moneyness (become risky) and others become a safe haven.

5. Understanding the Dynamics of the Crisis: A Chronology

In order to understand the dynamics of the crisis, we turn, in this section, to a formal statistical chronology of the recent financial crisis. We produce this chronology by locating structural breaks in panel data sets. We focus on the dating of the subprime shock, subsequent events in the money markets, the financial intermediaries at the center of the crisis, and the real economy. In this way, we identify the phases of the events and build a narrative of the crisis. In a way, this is a test the sequence of events predicted by the model.

A. Breakpoints Methodology

To produce a chronology of the financial crisis we need to find random but common breakpoints in a number of series. We estimate breakpoints in different panel data sets, where each panel has a recognizable economic meaning.

Most studies of breakpoints focus on a single series, treating series separately. There is a large literature on change point estimation for univariate series and only a small but emerging literature on estimating

common breakpoints in panel data.[35] For our study, basing the breakpoints on panel data offers several important advantages.

First, and most importantly, it is quite natural that a financial crisis would result in common breakpoints. The concept of a crisis means, at least intuitively, that a number of series show a common breakpoint, though the date of the breakpoint is not known. In fact, a definition of a financial crisis is that it is a common breakpoint in many money and banking time series. And a crisis is then followed by real effects. We seek to formalize this and, in the process, understand crises.

Second, it is possible to consistently estimate breakpoints using a panel, while there may be little or no power to looking at individual time series when there is not much data covering the crisis regime. In other words, in a univariate setting there may be little hope of detecting a regime switch when a single observation that may be an outlier can have a large effect on the estimate, or when one regime consists of only a few observations in time. In our setting the crisis period is relatively short and comes at the end of the sample.

We follow the estimation approach of Bai (2010). Briefly, the idea is to consider a panel of N series, as follows:

$$Y_{it} = \mu_{i1} + \sigma_{i1}\eta_{it}, \quad t = 1,2, \ldots, k_0$$

$$Y_{it} = \mu_{i2} + \sigma_{i1}\eta_{it}, \quad t = k_0+1, \ldots T$$

$$i = 1,2, \ldots, N$$

where $E(\eta_{it})=0$ and $var(\eta_{it})=1$, and for each i, η_{it} is a linear process; there are other assumptions as well; see Bai (2010). The breakpoint, k_0 in means and variances is unknown. Consistent estimation requires that there are breakpoints in either the means or the variances (or both). Assuming a common breakpoint is more restrictive than assuming random breakpoints in the different series in the panel. But, the assumption results in more precise estimation. The basic idea of Bai's approach is to exploit the cross-section information, sort of "borrowed power" relative to the non-panel approach.

The breakpoint is estimated with quasi-maximum likelihood (QML). Let

[35] On breakpoint estimation in general, see Perron (2005) and Hansen (2001). Bai (2010) provides the references to the other papers on the estimation of breakpoints in panels.

$$\hat{\sigma}_{i1}^2(k) = \frac{1}{k}\sum_{t=1}^{k}(Y_{it} - \bar{Y}_{i1})^2,\ \hat{\sigma}_{i2}^2(k) = \frac{1}{T-k}\sum_{t=k+1}^{T}(Y_{it} - \bar{Y}_{i2})^2.$$

The QML objective function for series i is:

$$k\ log\ \hat{\sigma}_{i1}^2(k) + (T-k) log\ \hat{\sigma}_{i2}^2(k),$$

multiplied by one half. Analogously, for N series:

$$U_{NT}(k) = k\sum_{i=1}^{N} log\ \hat{\sigma}_{i1}^2(k) + (T-k)\sum_{i=1}^{N} log\ \hat{\sigma}_{i2}^2(k).$$

The breakpoint estimator is $\hat{k} = argmin_k U_{NT}(k)$. Bai (2010) Theorem 5.1 shows that the breakpoint in this case can be consistently estimated.

Our approach is to group the data series into five different panels with recognizable economic content: (1) the real sector of the economy; (2) the subprime housing sector; (3) financial firms; (4) the unsecured money markets; and (5) the secured money markets. We further divide the financial firms to consider including and excluding Lehman. We also consider subsets of the real sector and subprime.

The real sector is represented by the S&P 500 index return, the VIX index (the Chicago Board Options Exchange Market Volatility Index), the JP Morgan High Yield Bond Index, and the Dow Jones CDX.IG index of investment grade credit derivative premia. The subprime sector is represented by the spreads on tranches of the ABX index (an index of derivative premia linked to subprime bonds), and two series of subprime bond spreads. The financial sector is represented by the CDS premia on ten banks, including Lehman Brothers (see Table 1). Finally, there are the returns on thirteen money market instruments, including four categories of commercial paper, fed funds, LIBOR, and the rates on seven categories of repo, including general collateral. The returns on the money market instruments are annualized overnight returns. We split the money market instruments into secured (repo), unsecured, and GC repo. Later, we also look at some individual money market series.

In terms of the number of series in a panel, precision is improved with a larger number of series. Clearly, the confidence intervals depend on N. But, as a practical matter N can also be small. Bai (2010) provides a sense of the precision with Monte Carlo experiments where the number of series, N, in the panel ranges from one to 100. It is also worth emphasizing what we saw above with spreads, namely, that during the crisis spreads do not become more highly correlated. Just the opposite, as market participants distinguish different degrees of moneyness among the different instruments.

After the first breakpoint is found, the subsequent breakpoints in each panel are (almost always) during the crisis period. But, these breakpoints are not necessarily chronologically ordered. So, chronologically the second breakpoint may come after the third breakpoint. Appendix C provides more information on the ordering of the breakpoints using the Bai procedure versus the chronological ordering. In what follows we show the breakpoints chronologically. The issue of the order in which the breakpoints are found and the chronological ordering not matching is discussed later and in Appendix C.

After finding a breakpoint in a panel, the individual series can be examined with a standard Chow test on each series. In unreported results, we find that all the individual series show breaks at the date of the break in the panel.

Finally, note that we are not testing sudden breaks against the alternative hypothesis of gradual or smooth structural changes. Chen and Hong (2012), for example, propose a test for smooth structural changes in time series, but not panels. The Bai procedure and the tests for smooth changes both test against the alternative of no change, and we cannot test to determine whether the change is sudden or gradual.

B. The Initial Crisis Breakpoint Chronology based on Spreads

We first focus on spreads and ask how the crisis evolved. Table 3 addresses this question. Table 3, Panel A, provides the breakpoints located for the different panel data sets shown in the table. The table also provides 99 percent confidence intervals for the breakpoints in terms of dates.[36] The main results are as follows.

The subprime shock occurs in the first quarter of 2007, on January 4, 2007. This is the "shock," corresponding to entering the Anxious state in the model. If we look only at the ABX tranches then the break occurs on January 25, 2007. If we only look at the two subprime series, the break is March 22, 2007. This timing is consistent with the failures of a number of subprime originators and the downgrades of subprime bonds by the rating agencies. See the chronology in Gorton (2010).

The next breakpoint occurs in the repo market on July 23, 2007. This is also when the breakpoint for the dealer banks' CDS occurs, whether we include Lehman or not. This is the start of the financial crisis, although as we will see subsequently haircuts do not rise until later. The breakpoints here confirm the

[36]Bai (2010) does not explain how to construct confidence intervals in the case of possible breaks in the means and variances of series. But, Professor Bai very kindly provided this as a private communication, which we appreciate very much.

start in the sense that the breakpoint for the repo spreads and for the dealer bank CDS premia is the same date. This is not surprising as the rise in repo spreads suggests that this form of financing is becoming riskier, raising the possibility of a run.

In unreported results, we also looked at thirteen categories of non-mortgage ABS. These spreads show a first break on July 19, 2007, with the 95% confidence interval of July 19, 2007-July 26, 2007. We also looked at the CDS premia of thirteen European banks; these show a first break on July 25, 2007.[37] The standard error shows a lower bound of July 23, 2007. In other words, there was no "contagion" from subprime to other securitization asset classes. And, there was no contagion to European banks later. This is consistent with the idea that a crisis is an information event corresponding to a shift from information-insensitive to information-sensitive for broad categories of asset classes—all securitizations! Since European banks were also involved in securitization, as holders of these bonds, they too were affected. (On a crisis as an information event, see Gorton (1985a), Dang, Gorton, and Holmström (2011) and Gorton and Ordonez (2014).)

The unsecured money market instruments, CP, fed funds, and LIBOR, show a breakpoint on August 8, 2007. Note that the 99 percent confidence intervals for the secured and unsecured money market instruments statistically distinguish the two dates for the repo markets and the unsecured money markets. There is a difference between the secured and unsecured markets. Repo is collateralized by a single bond, whereas unsecured instruments are backed by portfolios.[38]

The crisis, starting in the third quarter of 2007, only begins to affect the real sector later. The real sector, measured by the VIX, and the returns on the S&P500, the JPM HY Index, and the DJ CDX.IG, shows a break on January 3, 2008. The NBER dates the start of the recession in December 2007. If we separate the equity-related series from the bond-related series and only look at the VIX and the S&P, then the break is September 12, 2008 –nine months later. Lehman Brothers' failed on September 15, 2008, within the 99 percent confidence interval for the break in this latter case. The Troubled Asset Relief Program (TARP) became law on October 3, 2008.

In Table 4 we look at two single series, as one might expect that ABCP and GC repo spreads to behave differently. Indeed, ABCP by itself shows a break July 27, 2007, and the 99 percent confidence interval

[37] The banks included were Credit Agricole Group, BNP Paribas, Deutsche Bank, Barclays, Royal Bank of Scotland, Societe Generale, Banco Santander, Lloyds, UBS, UnitCredit, Credit Suisse and Rabobank.

[38] Keep in mind also that if a counterparty goes bankrupt, this does not affect ownership of the repo collateral, but CP holders must go into the bankruptcy process to try to recover their loan.

overlaps with the first break for repo. This is consistent with the run on ABCP, which resulted in banks taking conduit assets back via liquidity facilities, and then financing this at least in part via repo. Also, note that when looking at GC repo as a single series, there is a break on August 13, 2007.

We next build on the chronology by looking at subsequent break points.[39]

C. Dynamics of the Crisis: Subsequent Breakpoints

As mentioned above, the Bai (2010) procedure can be applied again to the two subperiods determined by the first break, to determine the next break in a given panel.[40] We first focus on the money market spreads. Table 3, Panel B, shows the second and third breakpoints in the money market spread panel data sets. The main findings are as follows.

There is a second breakpoint in the repo markets on August 14, 2008, *a month before Lehman*. The unsecured money markets, i.e., CP, Fed Funds, LIBOR, show a second break with the Lehman failure on Sept 12, 2008, but the Lehman failure of September 15th is within the 99 percent confidence interval. Once again there is a difference between the secured and unsecured markets.

There is a third break for all money market instruments December 15, 2008. Detail is also provided in Table 4. In this table we show the breaks for the single series of the GC repo spread and the single series of the ABCP spread.

Our findings on money market spreads are summarized with the chronology shown in Figure 6. We can relate this back to Figure 4. The Anxious state is realized in the first quarter of 2007. Figure 5 shows the other phases: Crisis, Runs and Depression. The Crisis phase corresponds to the period July 2007 through September 12, 2008, during which there are a number of breaks as fragility builds up. Repo breaks first, then asset-backed commercial paper (ABCP). Then the remaining unsecured money market instruments and finally GC repo show breaks. There are more breakpoints in the month *before* Lehman's failure, when repo, ABCP, GC repo, and unsecured (except ABCP) all show breaks. Then, The Runs occur, on Lehman September 15, 2008 going through December 2008.

This chronology reveals the importance of the Crisis phase, which is our focus. We turn to this next.

---

[39] Bai (2010): "Once the first break is obtained, we split the sample at the estimated break point, resulting in two subsamples. We then estimate a single break point in each of the subsamples, but only one of them is retained as our second estimator. The one that gives a larger reduction in the sum of squared residuals is kept." (p. 86)

[40] See Appendix C for more detail on the Bai procedure.

6. The Flight from Maturity

In this section we examine the Crisis phase, in particular the shortening of maturity, or flight from maturity. Fragility built up during the financial crisis because the maturities of money market instruments were reduced. This build-up led to the Lehman collapse, as money market instruments were then on a hair trigger. We can see this directly in the maturities of CP that was issued, which we examine first in subsection A. And, we can see it indirectly by looking at the term structure of spreads, which we examine in subsection B.

A. Commercial Paper: Issuance and Maturity Structure

Commercial paper is the only money market instrument where we can analyze the maturity structure of the paper issued using daily issuance data, but this is problematic because the mix of issuers is changing, as discussed below in Section 6.C.[41] Even so, we saw in Figure 2 that the firms that could issue still had to shorten their maturities.

The amounts of commercial paper issued by ABCP conduits and by financial firms dramatically declined during the crisis. Commercial paper issued by nonfinancial firms was less affected but was never quantitatively as important as ABCP and CP issued by financial firms. Issuance of commercial paper for various types of issuers and for different maturities is shown in Table 5 and Figure 2. The table shows the average daily issuance of commercial paper for the categories of issuer shown. The table also divides the data by time period. There are five time periods shown: before 2007, 2007 before the crisis (the Anxious phase), the Crisis before Lehman, the Run on Lehman, and the aftermath subsequent to December 2008.

Looking at the average issuance it is clear that the two nonfinancial CP categories (A2/P2 and AA) are the smallest issuers by far while ABCP is the largest and rises up until Lehman before collapsing. The other important category is AA financial. This is much smaller than ABCP. AA financial issuance shrinks during the crisis in the pre-Lehman period, recovers a bit, and then shrinks again.

[41] Krishnamurthy, Nagel and Orlov (2011) collected data on the maturity of repo used my money market mutual funds. Unfortunately, the data are quarterly. Looking at value-weighted maturities for a panel of repo consisting of collateral based on corporate debt securities, private label ABS/MBS, and agency debt, the first breakpoint is the fourth quarter of 2007.

Table 5 also shows the percentage of average issuance in each subperiod that has maturities in the maturity buckets shown. For a given category of issuer, looking down the column shows the trend in the maturity structure of the CP issued in that subperiod. The most important categories of issuer of CP in terms of amounts are ABCP and AA financial firms. Figure 7 is a bar chart which summarizes the trend in issuance of CP with maturities in the 1-4 day bucket, as a percentage of average issuance over the subperiod. ABCP shows a rising trend, even before the crisis. In the pre-crisis period 60 percent of the ABCP was 1-4 days maturity. During the crisis it rises in the pre-Lehman subperiod, and again during the Lehman subperiod. It then subsides. AA financial firms' issuance of 1-4 day CP declines over the first three subperiods. Then it rises when Lehman collapses.

The figure is suggestive. But, we now turn to examining the breaks in the series. Table 6 shows the results of testing for breakpoints with regard to the maturity structure of the outstanding paper. The table examines the short/long ratio which is the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window). The table shows that the first breakpoint occurs June 13, 2007 *before the break in repo rates*. In other words, maturities are shortening as concerns build-up. This is consistent with the model of Section 2. This is evidence of a build-up of fragility prior to our dating of the onset of the crisis.

The second breakpoint occurs in the immediate aftermath of the Lehman bankruptcy (September 15, 2008) on September 26, 2008. Figure 8 shows a measure of interbank credit risk, the LIBOR minus overnight index swap (OIS) rate spread, together with the 30-day rolling short/long ratio that we saw in Figure 2. The LIBOR minus OIS spread is the most common measure of interbank counterparty risk. The pattern is remarkable. The tendency for the ABCP maturity to shorten moves very closely with counterparty risk, as bank counterparties become riskier, their conduits are kept on a much shorter leash in terms of maturity in the CP market.

Table 7 provides more detailed information on the breakpoints for overnight CP issuance, one-month CP issuance, and three-month CP issuance. Table 7 shows the first break in overnight issuance was on May 31, 2007, several months before breaks in money market spreads. This is consistent with anecdotal evidence that maturities were shortening as lenders were becoming nervous in the spring and summer of 2007. For one-month issuance the first breakpoint is September 24, 2007. And for three-month

issuance the first breakpoint is March 8, 2007. Overnight issuance was increasing and three-month issuance was decreasing.

Unfortunately, we do not have issuance data for other money markets instruments. So, next we turn to examining the term structure of money market spreads for evidence of maturity shortening prior to and during the crisis. We examine the prediction of the model given by Proposition 1, that the term structure of spreads becomes positively sloped.

B. The Term Structure of Spreads

As discussed above, in Normal times the term structure of spreads is flat and near zero when the money market instruments are backed by high collateral quality or because of screening out all but high quality issuers in the unsecured money markets. Flat and low spreads are consistent with money market instruments displaying "moneyness" as in Figure 1. Market participants determine the longest maturity at which it is possible to maintain the moneyness of an instrument. At the acceptable maturities it is then a matter of indifference to participants which instruments are used as money, and the term structure of spreads should be flat. We find that in the pre-crisis period this was, in fact, the case.

The model predicts that the term structure of money market spreads should become positive subsequent to a shock—the Anxious state. This reflects a desire by borrowers to borrower at longer maturities and a desire by lenders to lend at shorter maturities. Lenders want to shorten maturity –the flight from maturity—because they want to be in a position to get their cash on very short notice. An upward sloping term structure of spreads is an indication of this concern on the part of the borrowers and the lenders. During the financial crisis spreads widen and the term structures of spreads steepen dramatically. The steepening of the term structure of spreads suggests an increase in fragility as lenders position themselves to demand cash at very short notice. But, we do not have volume data by maturity to confirm this for the other money market instruments.

Table 8 shows the spreads for overnight, one month, and three-month maturities for the different money market instruments during different subperiods.[42] Table 8 can be viewed by looking at the spreads for different maturities across a specific subperiod, or by looking at a given maturity and looking down across the subperiods.

[42] When the maturity is longer than one day, we use OIS rather than the federal funds target rate as the benchmark to determine the spread.

Some highlights from Table 8 are as follows. First, in the case of overnight federal funds, the actual (average) federal funds rate deviates from the target by the most in the aftermath of Lehman. As noted before, this is some evidence that it was becoming harder for the Fed to control money markets via intervention in the federal funds market.

With regard to GC repo, note that because GC repo uses U.S. Treasuries as collateral, it is safer than federal funds and so the GC repo spread is negative at all maturities prior to the crisis. In the pre-Lehman crisis period, there appears to be a flight to GC repo as the spread becomes much more negative, and is roughly flat across maturities. But, in the aftermath of Lehman note that the overnight GC repo spread becomes very negative(-56.32 bps), and the spread for one-month and three-month GC repo become positive, suggesting that lenders are scared of these maturities. This positive slope persists after December 2008.

The LIBOR spread curve is slightly positive in the pre-crisis period, but steepens during the crisis, and even more so after Lehman, shown in Figure 3. The commercial paper spread curves are near flat or slightly upward sloping prior to the crisis, but then steepen. AA financial CP and AA nonfinancial CP have larger negative overnight spreads which peak (at their highest negative values) after Lehman. These curves become very steep.

In the case of repo backed by private collateral, Panel C, the repo term structure of spreads is essentially flat in the pre-crisis period. During the crisis, the spreads are higher for longer maturities; the slope of the term structure rises. Looking down a column, the overnight spread is monotonically increasing for each repo category backed by private collateral, except for the cases where the collateral is corporate bonds. In the cases of one-month and three-month maturities, the spreads peak during the Lehman aftermath.

We now look directly at slopes of different points on the term structures of spreads. The slope measure is the difference between the one-month and one-day spreads, the difference between the three-month and one day spreads, and the difference between the three-month and one-month spread. The slope is, e.g.:

[Rate at one month – OIS rate for one month] minus [rate overnight – FF target overnight.

For longer maturities where there is no federal funds (FF) target, we use the OIS rate for that maturity. Table 9 shows different measures of the slope of the term structure of spreads at points on the term structure for the different money market instruments during different subperiods.

Looking down a column for a given money market instrument shows how the spread difference changed at that point on the term structure over the different subperiods. For example, in Panel A federal funds at the one month minus one day point saw the difference increase dramatically in the pre-Lehman and Lehman phases of the crisis. The same pattern appears for GC repo and LIBOR, also in Panel A. This same pattern holds for CP (Panel B) and repo (Panel C). It also holds for the middle column, the difference between the 3-month and overnight spreads, which also rise dramatically. Less dramatic is the 3-month minus 1-month spread difference.

It is perhaps easier to see what is going on with figures. As with Figure 3 above, Figures 9-11 display the term structure of spreads for LIBOR, federal funds, A2/P2 nonfinancial CP, and repo backed by ABS/RMBS/CMBS collateral rated less than AA. The LIBOR spread term structure progressively steepens during the crisis, as does the federal funds term structure of spreads. A2/P2 nonfinancial commercial paper dramatically steepens by December 15, 2008. Repo backed by ABS/RMBS/CMBS collateral rated less than AA shows the most dramatic increase in the term structure of spreads.

Figure 12 shows the 20-day moving average of the cross-sectional average for CP and repo, and the single series for fed funds and Libor. Panel A is the graph for the one-month minus overnight spread, and panel B is for the one-month minus overnight spread.

Table 10 shows the breakpoints for the slopes, where the slope is measured as the one-month/overnight spread. The breakpoint for the repo slope is July 23, 2007, the same date as the breakpoint in the repo spreads. Unsecured money market instruments' slopes break on August 8, 2007, also the same as the breakpoint for their spreads. The subsequent breakpoints are also the same, that is, they are coincident with the breakpoints for their respective spreads.

Overall, the quantity and price data point in the same direction, namely, that maturity shortens during the crisis.

C. CP Issuance and Screening

The unsecured money markets are based on screening. In addition to maturity shortening there may have been tightened screening of issuers. We find some suggestive evidence on this. First, we look at

the changes in S&P short-term credit ratings for 176 financial firms and report the results in Table 11. During the crisis of 2007-2009, a considerable proportion of these firms were downgraded. For example, 39% of firms with A-1+, the highest short-term rating, before the crisis were downgraded to A-1. And 36% of the firms rates A-1 were downgraded by one or more notches. Correspondingly, financial firms were forced to reduce their reliance on commercial paper. Figures 2 and 8 are then more remarkable, as even the best firms increasingly issue at shorter maturities.

Table 12 presents the aggregated balance sheet for financial firms in 2007 and 2008. The total commercial paper issued by financial firms was cut by $142 billion. In 2007, commercial paper accounted for 8.6% of total liabilities. This percentage decreased to 7.4% in 2008. Table 5, above, shows the maturities of the CP that continued to be issued.

D. Repo Haircuts

In this subsection we look at haircuts. With repo, lenders can ask for better collateral, and as we saw above, there was a flight to Treasuries. We have no data on the quantities of the various types of collateral used in the market. Another method for regaining the moneyness for repo when the collateral is privately-produced bonds is to raise haircuts. There might be several rounds of haircut increases, as well (not part of the model since it only had three dates). In the model, if this amount exceeds Γ then the bank is bankrupt.

As discussed in Gorton (2010) and Gorton and Metrick (2012), increasing repo haircuts corresponds to withdrawing cash from the banking system. For example, suppose a lender in the repo market deposits $100 million overnight at interest. To keep the deposit safe the bank provides $100 million of bonds (valued at market prices). The depositor takes possession of these bonds. The next morning suppose the borrower wants to renew or roll the repo. If the lender is nervous, he may offer to lend $90 million but wants to keep the $100 million of bonds at collateral (getting $10 million dollars of cash back from the borrower). This is called a 10 percent haircut. It corresponds to a withdrawal of $10 million from the bank because now the bank has to finance this amount from other sources.

In the model market participants first reduce maturities (during the Crisis) and only finally may exit (Run)—i.e., raise haircuts to 100 percent, withdrawing everything from the bank. Haircuts rise before the Run phase finally culminating in 100 percent haircuts. Table 13 shows the breakpoints in the panel

of the six categories of repo that use privately-produced collateral. Recall that the breakpoints in the slopes of the term structure of spreads for the different money market instruments are coincident with the breakpoints in spreads. With that in mind, the pattern of breakpoints in the haircuts is quite remarkable. Looking at the money market chronology of Figure 5 for reference, the first repo haircut breakpoint occurs on October 23, 2007, *after* the breaks in the spreads and slopes in the first cluster. The second breakpoint occurs on February 6, 2008, right around the time that the real effects of the crisis are felt. Not surprisingly, the third breakpoint is September 15, 2008, the day of Lehman's failure.

E. The Lehman Collapse

The subprime shock seems to have led to the sequence of Crisis and Run. In particular, the Crisis was happening though it was not noted by most observers. Prior to Lehman the overall maturity of money market instruments declined. By September 2008, Lehman financed most of its balance sheet with short-term repo financing, more than $200 billion a day.[43] Fragility had built up so that an enormous amount of debt was overnight, a hair trigger or exit option for lenders. The Lehman failure then occurs. Lehman was short $4.5 billion in cash on September 15, 2008.[44] There was no second shock—in the two shock theory-- in the sense that the dynamics of the crisis had created such a fragile situation that it seems that any event could well have caused a run.

F. Credit Derivative Premia

If fragility is building up, as we claim, then this buildup should be reflected in asset prices. If maturities are shortening, then dealer banks were increasingly facing systemic risk, so their likelihood of failure should be increasing. To examine this, the most relevant asset prices to look at are credit default swaps (CDS) referencing the dealer banks. We find that, indeed, this was the case.

Table 14 shows the breakpoints for the five year CDS on the nine financial firms listed in Table 1, where Lehman is excluded. As mentioned above, the first break in financial CDS is coincident with the first break in repo spreads and the first break in the term structure of repo spreads. The second break occurs

[43] See In re Lehman Brothers Holdings Inc., et al., Chapter 11 Case No. 09-13555, Report of Anton R. Valukas ("The Valukas Report"), footnote 10, p. 3.

[44] The Valukas Report, footnote 48, p. 12.

on February 8, 2008. This is a few days before President Bush signed the Economic Stimulus Act of 2008 on February 13, 2008, and before JP Morgan purchased Bear Stearns, on March 16, 2008.

The third break is on June 26, 2008 and the fourth break is September 11, 2008. Importantly, all of these breaks are *prior* to the Lehman failure on September 15, 2008, consistent with the idea that fragility is building up and this is reflected in the CDS spreads.

7. The Crisis Chronology

Our analysis provides a narrative of the crisis that is more precise than any that has been produced for any crisis to date.[45] And, the chronology is consistent with the predictions of the model. The findings can be summarized by referring to the chronology shown in Figure 13. Figure 13 lists (almost) all of the breakpoints discussed above, and also shows the major events that occurred.

The Anxious state occurs with the subprime shock on January 4, 2007. Then in the Crisis, the maturity of newly issued commercial paper shows a breakpoint in maturity issuance on June 13, 2007, which is when maturities started to shorten. Repo spreads and the term structures of repo slopes respond on July 23, 2007, the same time that dealer banks are shocked. On August 8, 2007, the other money market instruments are affected. Their spreads spike and their term structures of slopes increase. Lastly, repo haircuts significantly increase on October 23, 2007. Consistent with the model, haircuts are last. Finally, the real economy is affected starting on January 3, 2008. This is the end of phase one.

The crisis then evolves. Repo haircuts show a second breakpoint February 6, 2008, putting the financial firms at greater risk; their CDS shows a second break two days later, on February 8, 2008, reflecting this. JP Morgan buys Bear Stearns on March 16, 2008.

On June 26, 2008 there is a third break in the financial firms' CDS.

August 14, 2008 is the start of the second phase, perhaps anticipated by the CDS market. On this date, repo spreads and repo term structures of spreads have a break. September 11, 2008 there is another break in the financial firms' CDS. Unsecured money market instruments' spreads and their term structures of spreads have breaks on September 12, 2008.

[45] There are many narratives of crises. Well-known examples include Sprague (1910) and Andrew (1908 a, b) for crises during the U.S. National Banking Era and Wessel (2010) for the crisis of 2007-2008. But, these are not statistical narratives in the sense that we produce here.

The buildup culminates in the Run on repo when haircuts go up again, coincident—not surprisingly—with the collapse of Lehman on September 15, 2008. Repo haircuts going up in this case is the run on Lehman. The break is the same day.

The chronology raises a number of questions, some of which we can answer and some of which we can only speculate about. Here, we briefly discuss these questions.

First, if the subprime shock occurred in the first quarter of 2007, why did it not result in financial market crisis until the third quarter of 2007? We can only speculate about the answer to this question. One thing to keep in mind is that over-the-counter markets, like ABS/RMBS/CMBS markets and credit derivative markets for example, do not work like stock markets. Stock markets have centralized trading and readily observable prices. But over-the-counter markets have pairwise trading without centralized pricing. The price is only observed by the two counterparties. So, the price does not aggregate the information in the same way in OTC markets as in stock markets. It may simply take longer to percolate through markets. This is an issue for future research.

A second question is: Why was repo the first money market instrument to show a break? In the repo markets lenders became concerned about the quality of the bonds offered as collateral. Haircuts rose and repo market spreads also rose. See Gorton and Metrick (2012). Asset-backed commercial paper also faced runs but asset-backed commercial paper conduits were bailed out by their sponsors. Commercial paper spreads only showed a break later. As we noted above, repo has a single bond as collateral while ABCP was backed by a portfolio of ABS. The information implications of this are a subject for future research.

In 2007 Q2-Q3 ABCP conduits could not roll their CP (see Liang et al (2012)). Instead, they drew on their liquidity lines or financed via repo instead of CP. Liquidity lines were usually provided by the sponsoring banks of the ABCP conduits, so "drawing on the liquidity line" meant that banks ended up with the ABCP conduits' assets on their balance sheet. For example, HBOS announced on August 21, 2007 that its conduit Grampian would no longer issue CP, but that instead it would use liquidity facilities provided by HBOS. See Fitch (August 23, 2007). Perhaps lenders expected that ABCP conduits would be failed out.

Draw-downs under liquidity facilities resulted in assets covered by the facility coming back on intermediaries' balance sheets where they had to be funded. Much of this turns out to be funded in repo markets. Financial intermediaries financed the ABCP conduit assets in the repo market. In particular, money market funds (MMFs) increased their repo deposits/lending in 2008. MMFs became

emboldened after many of them were bailed out by their sponsors in the fourth quarter of 2007. MMFs were exposed to the ABCP market turmoil in the third and fourth quarters of 2007 and faced the prospect of losses during the fourth quarter of 2007. But, these losses were borne by the MMF sponsors; see McCabe (2010). So, risk is building up in MMFs because they become one place where former ABCP assets end up residing. Commercial banks are another apparent location, as they expand their balance sheets in 2008 (see He, Khang and Krishnamurthy (2010)).

8. Conclusion

The common view of a financial crisis is that it is the result of a "shock." And, the crisis of 2007-2008, in the standard view, really was the result of a second, larger, "shock," namely the failure of Lehman Brothers. Why was Lehman a much bigger "shock"? The standard view is that it was unexpected and was informative about the Fed's intentions to let a large bank fail, suggesting that other banks might be allowed to fail. In the two shock view, the second "shock" was independent of the first. We argue that a financial crisis is more than a "shock" and that the two shock view is wrong. That a large crisis is due to a large shock is not a very satisfying "explanation" and does not lead to policy recommendations. We argue that fragility builds up in the financial system, creating conditions for what might otherwise be a small shock to have a large impact. This is the Crisis phase. The maturities of money market instruments started declining in July 2007, and anecdotally started declining much earlier for Bear Stearns and Lehman Brothers. Whatever the information content of the Lehman collapse, market participants had to be in a position to respond by, in effect, withdrawing from the bank. Lenders were in that position because maturities had shortened prior to the Lehman collapse.

The importance of the Crisis phase is also discussed by Ó Gráda and White (2003) who study the panics of 1854 and 1857 based on the detailed records of the Emigrant Savings Bank in New York City. They show that these events were not characterized by immediate mass panic withdrawals from the bank. Depositors withdrew some, but not all of their money—akin to haircuts rising but not going to 100 percent. Later they withdrew more. Also see Iyer and Puri (2012). It is also the case that some crises do not progress to runs, as in the U.S. panics of 1884 and 1890. In these cases, the New York Clearing House issued loan certificates (allowing banks to conserve cash to meet withdrawals) and the economy

returned to the Normal state.[46] See Sprague (1910). In some cases, economies can arguably be said to have gotten stuck in the Crisis phase, as in Europe or Japan.

The financial crisis of 2007-2008 was started by a decline in home prices that followed a credit boom (the Anxious state). The Crisis began in July 2007 there was a run on ABCP and on repo. Money market instruments were suspect, and to recreate there moneyness market participants shortened maturities, fleeing from maturity, putting the financial system on a shorter and shorter leash. This is the build-up of systemic risk. Ultimately, this did not work, and then there are withdrawals from the banking system in the form of refusals to continue funding or increases in repo haircuts. This process is one of building fragility *during the crisis* which itself has already started. Lehman was a result of this build-up of fragility. In this sense systemic risk is endogenous. A crisis is a dynamic process.

[46] On clearing house loan certificates see Gorton (1984, 1985b) and Gorton and Mullineaux (1987).

Appendix A

In this appendix the model of Section II is solved and the proof for Proposition 1 is shown.

For Proposition 1, we show that both lenders and borrowers desire (as shown by their first order conditions (FOCs)) an upward sloping term structure of repo rates.

Recall that at each date t the bank's loan portfolio, L, must be financed by one- and two-period repo:

$$L = D_{t,1} + D_{t,2} + D_{t-1,2} \qquad \text{(A1)}$$

where $D_{t,1}$ and $D_{t,2}$ are chosen now, at date t, and $D_{t-1,2}$ was chosen last period, t-1. As long as the bank is solvent, an equilibrium is a path of one- and two-period interest rates, $\{R_{i,1}, R_{i,2}\}_{i=t}^{\infty}$ such that the market clears, i.e., (A1) holds, and banks and lenders maximize their profits and utilities, respectively. All agents are risk neutral and there is no discounting.

Recall that we assume that $p_{NN} \approx 1$ and $p_{NA} \approx 0$. For simplicity we assume these are strict equalities. So, in state N both borrowers and lenders behave as if the Normal state will continue forever, and so at any date the repo rates for one- and two-period loans are equal to R. We focus on the case where the economy has just entered state A and we ignore state N. Upon entering state A, either the economy will recover or it may end if AA occurs and there is a run, and surely ends with the bank's insolvency if the path is AAA. This structure simplifies the decision problem. Also, to simplify matters, we assume that, in fact, the outcome at date t, unbeknownst to the lenders, is $D_{t,1} > \widehat{D}_{t,1}$, but that lenders neglect this possibility (as in Gennaioli, Shleifer and Vishny (2012)).

Starting in state A at date t, we simply focus on the next two dates, t+1 and t+2. Let C_i be consumption at date i. Recall that lenders neglect the risk of a run. Then the representative lender chooses $D_{t,1}$ and $D_{t,2}$ to:

$$\max \sum_{i=t}^{\infty} C_i$$

$$s.t.\ C_t \leq R_{t-1,1}D_{t-1,1} + R_{t-2,2}D_{t-2,2} - [D_{t,1} + D_{t,2}]$$

Note that:

$$E[C_{t+1}] = (p_{AN} + p_{AA})(R_{t,1}D_{t,1} + R_{t-1,2}D_{t-1,2}) \qquad \text{(A2)}$$

$$E[C_{t+2}] = (p_{AN}p_{NN} + p_{AA}p_{AN})\big(R_{t+1,1}D_{t+1,1} + R_{t,2}D_{t,2}\big) + p_{AA}^2\mathrm{E}[\Sigma_{t+2}]. \qquad \text{(A3)}$$

Note that $p_{AN} + p_{AA} = 1$ and that $R_{t-1,2}D_{t-1,2}$ is predetermined, having been chosen at t-1. Recall that $\Sigma_t \equiv \phi_t[D_{t-1,1} + D_{t-2,2} + D_{t-1,2}]$ is the value of the collateral at date t.

The FOCs for $D_{t,1}$ and $D_{t,2}$ are, respectively:

$$(p_{AN} + p_{AA})R_{t,1}^{NE} = 1$$

$$(p_{AN}p_{NN} + p_{AA}p_{AN})R_{t,2}^{NE} + p_{AA}^2E[\phi_{t+2}|AA] = 1$$

Since $p_{AN} + p_{AA} = 1$, $R_{t+1}^{NE} = 1$. Note that $p_{AN}p_{NN} + p_{AA}p_{AN} = 1 - p_{AA}^2$ since $p_{NA} \approx 0$. So, $R_{t,2}^{NE} = \frac{1}{p_{AA}^2} - E[\phi_{t+2}|AA] > 1$. Therefore, $R_{t,2}^{NE} > R_{t,1}^{NE} = 1$. I.e., the term structure is upward sloping. The reason is that the lender is bearing the risk of the bank becoming insolvent, in the case of AA.

The bank also neglects the risk of a run. The bank chooses $D_{t,1}$ and $D_{t,2}$ to:

$$\max\,(p_N + p_A)\big(RL - R_{t,1}D_{t,1}\big) + (p_N^2 + p_Ap_N)(RL - R_{t,2}D_{t,2})$$

$$s.t.\ L \le D_{t,1} + D_{t,2} + D_{t-1,2}$$

$$D_{t,1} < \gamma\widehat{D}_{t,1}$$

Let η be the LaGrange multiplier on the liquidity risk management constraint. The FOCs for $D_{t,1}$ and $D_{t,2}$ are, respectively:

$$(p_N + p_A)\big(R - R_{t,1}\big) = \eta \qquad \text{(A4)}$$

$$(p_N^2 + p_Ap_N)\big(R - R_{t,2}\big) = 0 \qquad \text{(A5)}$$

which results in $R_{t,2} > R_{t,1}$, due to the bank wanting to attract lenders to the two-period loans to avoid liquidity risk.

So, both borrowers and lenders prefer an upward-sloping term structure in the Anxious state. This is Proposition 1.

Appendix B: Seasonals in Money Market Spreads

In this appendix we briefly discuss the calendar effects or "seasonals" in money market spreads.

Appendix Table B1 shows regressions of the money markets spreads on calendar dummies, and shows that "seasonals" are important in money market spreads. There are spikes in many of the spreads at certain calendar dates. Just before the quarter end (five days before to the day before) and the date of the quarter-end and day after, show the largest increases. But, note that the largest increases on those dates are in the repo markets. Repo using all categories of private securities as collateral show significant spikes in spreads around the quarter-end. For example, repo that uses collateralized loan obligation tranches rates AA-AAA spikes by 77 basis points the day of the quarter-end and the next day. Repo backed by asset-backed securities composed of auto loans, credit card receivables, or student loans rated AA-AAA also spikes by 71 basis points on those days. Unsecured money market instruments show much lower increases on those dates. For example, LIBOR goes up 4 basis points, A1/P1 Financial CP goes up by 8 basis points, and A1/P1 asset-backed commercial paper goes up by 9 basis points.

There is more seasonal pressure on repo markets. A seasonal increase in the spread in repo suggests that borrowers are willing to pay more for cash at these seasonal dates than at other dates to finance the collateral. But, the depositors/lenders, on the other hand, appear to want their cash (and not the collateral) at these dates.

Why is there a large demand for cash at these dates? Large movements of cash which go from one party to another, especially if one party is the government so cash leaves the economy, could cause these spikes in spreads. In the period before the Federal Reserve System there were seasonal spikes in interest rates when cash had to move from cities to rural areas for planting season and then later for harvesting season. Indeed, such spikes were viewed as creating fragility in the system and were a major motivation for the founding of the Federal Reserve System.[47]

In the modern era since the founding of the Federal Reserve System there are several possible candidates for explaining seasonals. One candidate for large cash movements is the payment of estimated taxes by corporations. Another possibility is quarter-end "window dressing," which might show up for example in the excess reserves of banks, if they are engaged in window dressing.

[47] On seasonals in the money markets prior to the Fed see Kemmerer (1911). On seasonals and fragility prior to the Fed see Miron (1986). And, on the elimination of some of the seasonals in interest rates once the Fed comes into existence, see Mankiw, Miron and Weil (1987).

We examine these issues in Table B2. The table contains the intercepts on each money market instrument with no controls, in the first column, and also with the date dummies from Table B1, in the second column. The next two columns show the change in the intercept when two tax variables are (separately) used in the panel regression. The two variables are the same. In both columns, we report the fitted values. We first estimate the parameters for tax flow process. Then we use the average tax flow to replace the actual tax flow and calculate the fitted value. For the variable "Tax, all days average", we assume tax flow equals the average tax flow across all days. For the variable "Tax, Normal days", we assume that tax flow equals the average tax flow across normal days, excluding quarter-end, beginning, middle and end of each month. The second average tax flow is smaller than the first one.

The last column includes U.S. commercial banks' excess reserves. The intercept is adjusted for these variables by estimating the coefficient on the variable and then adding or subtracting the coefficient times the average of that variable. So, for example, in column 3 the coefficient times the average inflow of taxes to the government, averaged over all (business) days, shows no effect, as the intercepts change very little. When the middle of the month is excluded, the intercept does go down in most cases, but not by much.

Inclusion of the excess reserves variable does reduce the intercept for repo categories, but not by as much as the calendar dummies that we started with.

These calendar effects are a subject for future research.

Appendix C: Chronology Breakpoints

In this appendix we briefly discuss the ordering of breakpoints.

As explained briefly in the main text, the Bai procedure finds a breakpoint for the given panel. The second breakpoint looks at the two subperiods defined by the first breakpoint and minimizes the sum of squared residuals over the whole sample using QML. The second breakpoint we find is usually after the date of the first breakpoint, but need not be. This means that we do not condition on the first breakpoint. In other words, the second breakpoint could be before the first breakpoint. Similarly, the third breakpoint is determined by looking at the ALL the subperiods determined by the first and second breakpoints.

The issues are illustrated by Figure C1, which shows two possible Bai orderings. The first breakpoint in both panels, A and B, is the crisis date. This is true in the data. In Panel A, the first three breakpoints occur at the crisis date and then chronologically in order. But, breakpoint four is before the crisis date. In general we are only interested in the first three breakpoints. However, we always calculate the fourth breakpoint because sometimes the ordering looks more like what is shown in Panel B.

In Panel B, the fourth breakpoint occurs during the crisis, and comes before the second breakpoint. But, the third breakpoint is before the crisis onset.

In order to understand the sensitivity of the procedure, particularly given the seasonals, we show the ordering according to the Bai algorithm and the chronological ordering. Table B1 provides examples for the most important panels. It illustrates the differences between the breakpoints found by the Bai algorithm and the chronological ordering of the breakpoints. In the table “Algorithm Order” equal 1 means that is the first breakpoint fund by the Bai procedure. “Chronological Order” means that after we found four breakpoints we sorted them chronologically and labeled them 1 through 4.

These issues are shown in Table C1.

References

Acharya, Viral, Philipp Schnabl, and Gustavo Suarez (2011), "Securitization without Risk Transfer," *Journal of Financial Economics* 107, 515-536.

Allen, Linda and Anthony Saunders (1992), "Bank Window Dressing: Theory and Evidence," *Journal of Banking and Finance* 16, 585-623.

Andrew, A. Piatt (1908a), "Substitutes for Cash in the Panic of 1907," *Quarterly Journal of Economics* 22, 290–99.

Andrew, A. Piatt (1908b), "Hoarding in the Panic of 1907." *Quarterly Journal of Economics* 22, 497–516.

Bai, Jushan (2010), "Common Breaks in Means and Variances for Panel Data," *Journal of Econometrics* 157, 78-92.

Bech, Morten L., Elizabeth Klee, and Viktors Stebunovs (2012), "Arbitrage, Liquidity and Exit," Finance and Economics Discussion Series 2012-21, Board of Governors of the Federal Reserve System.

Bernanke, Ben (2010), "Causes of the Recent Financial and Economic Crisis," Statement by Ben S. Bernanke, Chairman, Board of Governors of the Federal Reserve System, before the Financial Crisis Inquiry Commission, Washington D.C. (September 2, 2010); see http://www.federalreserve.gov/newsevents/testimony/bernanke20100902a.htm .

Bernanke, Ben (2009), "Reflections on a Year in Crisis." Speech at the Federal Reserve Bank of Kansas City's Annual Economic Symposium, Jackson Hole, Wyoming, August 21, 2009.

Blinder, Alan (2009), "Six Errors on the Path to the Financial Crisis", *New York Times* January 25.

Boyd, John, Gianni De Nicolò, and Elena Loukoianova (2011), "Banking Crises and Crisis Dating: Theory and Evidence," International Monetary Fund, working paper.

Brunnermeier, Markus and Martin Oehmke (2013), "The Maturity Rat Race," *Journal of Finance* 68, 483-521.

Calomiris, C.W., (1994), "Is the Discount Window Necessary: A Penn-Central Perspective," Federal Reserve Bank of St. Louis *Review*, 76, 31-56.

Calomiris, C.W., (1989), "The Motivations for Loan Commitments Backing Commercial Paper," Journal of Banking and Finance 1, 271-77.

Calomiris, Charles, Charles Himmelberg, and Paul Wachtel (1995), "Commercial Paper, Corporate Finance, and the Business Cycle: A Microeconomic Perspective," *Carnegie-Rochester Conference Series on Public Policy* 42, 203-250.

Chen, Bin and Yongmiao Hong (2012), "Testing for Smooth Structural Changes in Time Series Models via Nonparametric Regression," *Econometrica* 80, 1157-1183.

Covitz, Daniel M., Nellie Liang, and Gustavo A. Suarez (Forthcoming), "The Evolution of a Financial Crisis: Collapse of the Asset-Backed Commercial Paper Market," *Journal of Finance* 68, 815-848.

Crabbe, Leland and Mitchell Post (1994), "The Effect of a Rating Downgrade on Outstanding Commercial Paper," *Journal of Finance* 49, 39-56.

Dang, Tri Vi, Gary Gorton and Bengt Holmström (2011), "Financial Crises and the Optimality of Debt for Liquidity Provision."

Diamond, Douglas (1991), "Debt Maturity Structure and Liquidity Risk," *Quarterly Journal of Economics* 56, 709-738.

Fender, Ingo and Martin Scheicher (2008), "The ABX: How Do the Markets Price Subprime Mortgage Risk?," BIS *Quarterly Review* (September), 67-81.

Financial Crisis Inquiry Commission (2011), Final Report of the National Commission on the Causes of the Financial and Economic Crisis in the United States (Public Affairs).

Fitch Ratings (2007), "Asset-Backed Commercial Paper & Global Banks Exposure—10 Key Questions," *Special Report* (September 12, 2007).

Fons, Jerome and Andrew Kimball (1991), "Defaults and Orderly Exits of Commercial Paper Issuers, 1972-1990," *Moody's Special Report* (January).

Fostel, Ana and John Geanakoplos (2008), "Leverage Cycles and the Anxious Economy," *American Economic Review* 98(4), 1211-1244.

Gorton, Gary (2010), Slapped by the Invisible Hand: The Panic of 2007 (Oxford University Press).

Gorton, Gary (1999), "Pricing Free Bank Notes," *Journal of Monetary Economics* 44 (1999): 33-64.

Gorton, Gary (1996), "Reputation Formation in Early Bank Note Markets," *Journal of Political Economy*, Vol. 104, No. 2, 346-397.

Gorton, Gary (1985a), "Bank Suspension of Convertibility," *Journal of Monetary Economics* 15: 177-193.

Gorton, Gary (1985b), "Clearinghouses and the Origin of Central Banking in the United States," *Journal of Economic History* 45 (2): 277–83.

Gorton, Gary. 1984. "Private Bank Clearinghouses and the Origins of Central Banking." *Business Review—Federal Reserve Bank of Philadelphia*, January/February, 3–12.

Gorton, Gary and Andrew Metrick (2012), "Securitized Banking and the Run on Repo," J*ournal of Financial Economics* 104, 425-451.

Gorton, Gary and Andrew Metrick (2011), "Securitization," chapter in the Handbook of the Economics of Finance, volume 2, edited by George Constantinides, Milton Harris, and René Stulz, Elsevier, forthcoming.

Gorton, Gary, and Don Mullineaux. 1987. "The Joint Production of Confidence: Endogenous Regulation and Nineteenth Century Commercial Bank Clearinghouses." *Journal of Money, Credit, and Banking* 19 (4): 458–68.

Gorton, Gary and Guillermo Ordoñez (2012), "Collateral Crises," *American Economic Review*, 104, 343-378.

Griffiths, Mark and Drew Winters (2005), "The Turn of the Year Money Markets: Tests of the Risk-Shifting Window Dressing and Preferred Habitat Hypothesis," *Journal of Business* 78, 1337-1363.

Hansen, Bruce (2001), "The New Econometrics of Structural Change: Dating Breaks in U.S. Labor Productivity," *Journal of Economic Perspectives* 15, 117-128.

He, Zhiguo, Ingu Khang, and Arvind Krishnamurthy (2010), "Balance Sheet Adjustment in the 2008 Crisis," *IMF Economic Review* 58, 118-156.

Kemmerer, E. W. (1911), "Seasonal Variation in the New York Money Market," *American Economic Review* 1, 33-49.

Komotin, Vladimir and Drew Winters (2006), "Quarter-End Effects in Banks: Preferred Habitat or Window Dressing?," *Journal of Financial Services Research* 29, 61-82.

Krishnamurthy, Arvind, Stefan Nagel, and Dmitry Orlov (2011), "Sizing Up Repo," working paper.

Lucas, Robert (2009), "In Defense of the Dismal Science," *The Economist*, August 8:67.

Mankiw, N. Gregory, Jeffrey Miron, and David Weil (1987), "The Adjustment of Expectations to a Change in Regime: A Study of the Founding of the Federal Reserve," *American Economic Review* 77, 358-374.

McCabe, Patrick (2010), "The Cross Section of Money Market Fund Risks and Financial Crises," Federal Reserve Board, working paper no. 2010-51.

Meltzer, Allan (2009), "What Happened to the 'Depression'?," *Wall Street Journal*, April 31, 2009.

Miron, Jeffrey (1986), "Financial Panics, the Seasonality of the Nominal Interest Rate and the Founding of the Fed," *American Economic Review* 76, 125-140.

Moody's Investors Services (2007), "Moody's Update on Bank-Sponsored ABCP Programs: A Review of Credit and Liquidity Issues," International Structured Finance, *Special Report* (September 12, 2007).

Moody's Investors Services (2003), "The Fundamentals of Asset-Backed Commercial Paper," Structured Finance, *Special Report* (February 3, 2003).

Musto, David (1997), "Portfolio Disclosures and Year-End Price Shifts," *Journal of Finance* 52, 1861-82.

Nayar, Nandkumar, and Michael S. Rozeff (1994), "Ratings, Commercial Paper, and Equity Returns," *Journal of Finance* 49, 1431-1449.

Ó Gráda, Cormac, and Eugene White (2003), "The Panics of 1854 and 1857: A View from the Emigrant Industrial Savings Bank," *Journal of Economic History* 63 (1), 213–40.

Perron, Pierre (2006), "Dealing with Structural Breaks," chapter in Palgrave Handbook of Econometrics, Volume 1, edited by Terence Mills and Kerry Patterson (Palgrave Macmillan), 278-352.

Sprague, O. M. W. (1910), History of Crises under the National Banking System, Senate Document 538 (Washington DC: Government Printing Office).

Stein, Jeremy (2012), "Monetary Policy as Financial Stability Regulation," *quarterly Journal of Economics* 127, 57-09.

Wessel, David (2010), In Fed We Trust: Ben Bernanke's War on the Great Panic (Crown Business).

Table 1: Data Sources and Sample Periods

This table summarizes the data used in the paper. Their sources, sample periods and short descriptions are presented.

Variable	Source	Sample Periods		Description
		Beginning	End	
VIX	CBOE	1/1/2000	4/30/2009	CBOE Volatility Index
S&P 500	Standard & Poor's	1/1/2000	4/30/2009	Standard & Poor's 500 Index return
JPM HY Index	Dealer Bank	4/10/2003	4/30/2009	J.P. Morgan High Yield Index
DJ CDX.IG	Dealer Bank	4/10/2003	4/30/2009	Dow Jones CDX Index (Investment grade)
ABX	Dealer Bank	1/19/2006	4/30/2009	Markit ABX.HE Index, 2006-1. AAA, BBB and BBB-
HEL	Dealer Bank	1/19/2006	1/3/2008	Home Equity Loan ABS spreads, AAA and BBB ratings
Financial CDS	Bloomberg	11/6/2002	4/30/2009	5 Year CDS for Bank of America, JP Morgan, Citigroup, Wells Fargo, Wachovia, Goldman Sachs, Merrill Lynch, Morgan Stanley, Lehman Brother and Bear Stearns.
Interbank Money Markets				
Fed Fund	Bloomberg	12/20/2001	4/30/2009	Effective Federal Fund rate
LIBOR	Bloomberg	12/20/2001	4/30/2009	LIBOR
OIS	Bloomberg	12/20/2001	4/30/2009	Overnight indexed swap
Commercial Paper				
A2/P2 Nonfinancial	Federal Reserve	12/20/2001	4/30/2009	SIC code: 100-5999, 7000-9999. Programs with at least one "2" rating but no ratings other than "2"
AA Asset-backed	Federal Reserve	12/20/2001	4/30/2009	SIC code: 6189. Programs with at least one "1" or "1+" rating but no ratings other than "1"
AA Financial	Federal Reserve	12/20/2001	4/30/2009	SIC code: 6000-6999, excluding 6189. Programs with at least one "1" or "1+" rating but no ratings other than "1"
AA Nonfinancial	Federal Reserve	12/20/2001	4/30/2009	SIC code: 100-5999, 7000-9999. Programs with at least one "1" or "1+" rating but no ratings other than "1"
Repo Categories				
GC	Bloomberg	12/20/2001	4/30/2009	General collateral repo rate
<AA ABS-RMBS / CMBS	Dealer Bank	10/3/2005	4/30/2009	Residential mortgage-backed security (RMBS) or commercial mortgage-backed security (CMBS) with ratings less than AA
A-AAA ABS-Auto / CC / SL	Dealer Bank	10/3/2005	4/30/2009	Asset-backed securities (ABS) comprised of auto loans, credit-card receivables, or student loans, with ratings between A and AAA, inclusive.
AA-AAA ABS-RMBS / CMBS	Dealer Bank	10/3/2005	4/30/2009	Residential mortgage-backed security (RMBS) or commercial mortgage-backed security (CMBS) with ratings between AA and AAA, inclusive.
AA-AAA CLO	Dealer Bank	10/3/2005	4/30/2009	Collateralized loan obligations (CDO) with ratings between AA and AAA, inclusive.
AA-AAA Corporates	Dealer Bank	10/3/2005	4/30/2009	Corporate bonds rated between AA and AAA, inclusive.
BBB+ / A Corporates	Dealer Bank	10/3/2005	4/30/2009	Corporate bonds rated between BBB+ and A, inclusive.

Table 2: Overnight Spreads Comparison

This table presents overnight spreads for different money market instruments. The spread is defined as the difference between the promised contractual rate paid on the money market instrument and the federal funds target rate. All spreads are adjusted for seasonal effects by regressing them on the calendar dummies and then using the intercepts. For more details about the regression please refer to Table B1. We first divide the sample into two periods. Before the crisis is from Jan. 1, 2001 to Jul. 22, 2007 (the first breakpoint in repo) and during the crisis, for Jul. 23, 2007 to Apr. 29, 2009. The crisis period is further divided into three subperiods: (1) Pre-Lehman: Jul. 23, 2007 to Aug. 14, Aug 2008; (2) Lehman: Aug. 15, 2008 to Dec. 14, 2008; (3) After Dec 2008: Dec. 15, 2008 to Apr. 29, 2009. t-statistics for the null hypothesis spread=0 are reported in parentheses.

	Before the Crisis	During the Crisis	Crisis: Pre-Lehman	Crisis: Lehman	Crisis: After Dec 2008
	Intercept	Intercept	Intercept	Intercept	Intercept
Federal Funds	-0.32	-8.06	-3.32	-37.04	6.97
	(-1.54)	(-4.30)	(-2.44)	(-6.00)	(5.46)
GC Repo	-3.83	-22.49	-23.27	-56.32	11.02
	(-14.38)	(-7.70)	(-6.96)	(-7.53)	(6.76)
LIBOR	5.33	15.46	16.76	13.85	13.37
	(33.06)	(4.65)	(10.76)	(1.03)	(7.55)
A2/P2 Nonfinancial CP	8.97	80.03	47.52	172.89	87.34
	(24.46)	(15.66)	(28.27)	(11.53)	(17.33)
AA Asset-backed CP	1.47	40.28	37.52	50.78	38.40
	(8.34)	(12.98)	(27.49)	(5.05)	(16.13)
AA Financial CP	-1.51	-9.11	-5.90	-35.51	7.30
	(-8.65)	(-5.30)	(-6.59)	(-6.10)	(4.83)
AA Nonfinancial CP	-1.90	-7.47	-3.01	-36.53	7.73
	(-10.98)	(-3.89)	(-3.33)	(-5.44)	(4.75)
<AA ABS-RMBS / CMBS	10.16	98.59	49.12	136.94	207.36
	(8.36)	(17.18)	(13.07)	(8.90)	(74.21)
A-AAA ABS-Auto / CC / SL	3.23	56.70	30.07	83.06	108.90
	(3.070)	(12.90)	(8.51)	(5.09)	(34.65)
AA-AAA ABS-RMBS / CMBS	5.16	79.75	37.96	110.39	173.64
	(4.24)	(15.13)	(10.65)	(7.01)	(70.07)
AA-AAA CLO	5.16	93.18	45.75	125.99	202.31
	(4.24)	(16.45)	(11.80)	(8.38)	(74.11)
AA-AAA Corporates	-0.82	15.16	11.58	19.18	21.65
	(-0.92)	(3.71)	(3.71)	(1.02)	(8.73)
BBB+ / A Corporates	1.91	25.71	18.45	35.82	37.11
	(2.04)	(6.27)	(5.67)	(1.94)	(13.14)

Table 3: Crisis Chronology

This table presents the common breakpoints following Bai's (2010) procedure for different groups of data. Panel A shows the first breakpoints and the lower and upper bound of their 99% confidence intervals. The number of securities, the data frequency and the sample period for each group are also reported. Panel B shows the second and third breakpoints in the money market spreads data. Financial CDS include the 5-year credit default swaps (CDS) on 10 top U.S. financial institutions, including commercial banks and dealer banks. The list of banks is in Table 1. CP includes four categories of commercial paper: A2/P2 nonfinancial, A1/P1 asset-backed commercial paper, A1/P1 financial, and A1/P1 nonfinancial. Repo include six categories of repo, which differ by the type of privately-produced collateral used as backing: AAA/Aaa-AA/Aa asset-backed securities (ABS), including residential mortgage-backed (RMBS) and commercial mortgage-backed securities (CMBS), RMBS and CMBS with ratings between AA and AAA , AAA/Aaa-A/A auto loan-backed, credit card receivables-backed and student loan-backed ABS, AAA/Aaa-AA/Aa collateralized loan obligations (CLOs), AAA/Aaa-AA/Aa corporate bonds, and A/A-Baa/BBB+ corporate bonds.

Panel A: Common Break Points

Description	Num. of Securities	Break Point	Lower bound	Upper bound	Frequency	Beginning	End
Real Sector: VIX and S&P 500	2	2008/9/12	2008/9/12	2008/9/15	Daily	2000/1/1	2009/4/30
Real Sector: VIX, S&P 500, JPM HY Index, DJ CDX.IG	6	2008/1/3	2008/1/3	2008/1/10	Weekly	2003/4/10	2009/4/30
Subprime: ABX only	3	2007/1/25	2007/1/24	2007/1/29	Daily	2006/1/19	2009/4/30
Subprime: HEL only	2	2007/3/22	2007/3/22	2007/3/29	Weekly	2006/1/19	2008/1/3
Subprime: ABX & HEL	5	2007/1/4	2007/1/4	2007/1/11	Weekly	2006/1/19	2008/1/3
Financial CDS: Include Lehman	10	2007/7/23	2007/7/23	2007/7/24	Daily	2002/11/6	2008/9/12
Financial CDS: Exclude Lehman	9	2007/7/25	2007/7/25	2007/7/26	Daily	2002/11/6	2009/4/30
Money Market: CP, Fed Fund, GC, LIBOR, Repo	13	2007/7/23	2007/7/23	2007/7/24	Daily	2005/10/3	2009/4/30
Money Market: Repo	6	2007/7/23	2007/7/20	2007/7/25	Daily	2005/10/3	2009/4/30
Money Market: CP, Fed Fund, GC, LIBOR	7	2007/8/8	2007/8/8	2007/8/9	Daily	2005/10/3	2009/4/30

Panel B: Multiple Break Points								
Description	**Breaks**	**Number of Securities**	**Break Point**	**Lower bound**	**Upper bound**	**Frequency**	**Beginning**	**End**
CP, Fed Fund, GC, LIBOR, Repo	First	13	7/23/2007	7/23/2007	7/24/2007	Daily	10/3/2005	4/30/2009
	Second	13	8/14/2008	8/14/2008	8/15/2008	Daily	10/3/2005	4/30/2009
	Third	13	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR	First	7	8/8/2007	8/8/2007	8/9/2007	Daily	10/3/2005	4/30/2009
	Second	7	9/12/2008	9/12/2008	9/16/2008	Daily	10/3/2005	4/30/2009
	Third	7	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009
Repo	First	6	7/23/2007	7/20/2007	7/25/2007	Daily	10/3/2005	4/30/2009
	Second	6	8/14/2008	8/14/2008	8/15/2008	Daily	10/3/2005	4/30/2009
	Third	6	12/15/2008	12/12/2008	12/17/2008	Daily	10/3/2005	4/30/2009
All CP	First	13	7/27/2007	7/26/2007	7/31/2007	Daily	10/3/2005	4/30/2009
	Second	13	9/12/2008	9/11/2008	9/17/2008	Daily	10/3/2005	4/30/2009
	Third	13	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009
Unsecured (Excluding ABCP)	First	7	8/6/2007	8/3/2007	8/8/2007	Daily	10/3/2005	4/30/2009
	Second	7	9/12/2008	9/11/2008	9/17/2008	Daily	10/3/2005	4/30/2009
	Third	7	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009

Table 4: Spread Break Detail

This table presents the common breakpoints for two single series, overnight ABCP spread and overnight GC spread. Three breakpoints and the lower and upper bound of their 99% confidence intervals, as well as the number of securities, the data frequency and the sample period for each series are reported.

Description	Breaks	Number of Securities	Break Point	Lower bound	Upper bound	Frequency	Beginning	End
ABCP	First	1	7/27/2007	7/20/2007	8/6/2007	Daily	10/3/2005	4/30/2009
	Second	1	9/12/2008	9/5/2008	10/3/2008	Daily	10/3/2005	4/30/2009
	Third	1	10/16/2008	10/16/2008	10/17/2008	Daily	10/3/2005	4/30/2009
GC	First	1	8/13/2007	8/1/2007	8/24/2007	Daily	10/3/2005	4/30/2009
	Second	1	9/12/2008	9/4/2008	10/6/2008	Daily	10/3/2005	4/30/2009
	Third	1	12/15/2008	12/1/2008	1/12/2009	Daily	10/3/2005	4/30/2009

Table 5: Commercial Paper Issuance

This table presents the issuance of commercial paper for various types of issuers and for different maturities. The first column shows average total issuance per day and the following columns shows the percentage of issuance for different maturities. The subperiods are as follows: Before 2007: Jan. 1, 2001 to Jan. 1, 2007; Pre-crisis：Jan. 1, 2007 to Jul. 22, 2007; Crisis: Pre-Lehman: Jul. 23, 2007 to Aug. 14, Aug 2008; Crisis: Lehman: Aug. 15, 2008 to Dec. 14, 2008; Crisis: After Dec. 15, 2008 to Apr. 29, 2009. The data is from Federal Reserve H.15 Release, Historical Data.

	Period	Avg. Issuance $ millions	1-4 days	5-9 days	10-20 days	21-40 days	41-80 days	>=80 days
A2/P2 Nonfinancial	Before 2007	4,276.5	65%	8%	7%	13%	4%	1%
	Pre-crisis	6,045.7	77%	7%	5%	8%	3%	1%
	Crisis: Pre-Lehman	7,635.8	78%	7%	6%	6%	2%	1%
	Crisis: Lehman	5,660.3	70%	11%	10%	7%	2%	1%
	Crisis: After Dec 2008	3,222.9	69%	10%	9%	8%	2%	1%
AA Asset-backed	Before 2007	38,107.2	49%	5%	5%	25%	8%	7%
	Pre-crisis	60,945.9	61%	4%	4%	20%	5%	6%
	Crisis: Pre-Lehman	70,064.8	67%	6%	5%	13%	4%	5%
	Crisis: Lehman	71,613.5	74%	5%	3%	8%	3%	6%
	Crisis: After Dec 2008	27,303.6	61%	8%	3%	16%	4%	8%
AA Financial	Before 2007	18,080.0	77%	6%	4%	6%	4%	3%
	Pre-crisis	16,017.1	67%	7%	5%	7%	4%	9%
	Crisis: Pre-Lehman	9,712.8	55%	7%	6%	11%	6%	14%
	Crisis: Lehman	12,403.5	74%	6%	4%	5%	2%	10%
	Crisis: After Dec 2008	8,563.6	75%	5%	3%	7%	3%	8%
AA Nonfinancial	Before 2007	3,165.4	63%	8%	8%	12%	7%	2%
	Pre-crisis	1,475.2	53%	9%	9%	10%	11%	7%
	Crisis: Pre-Lehman	1,452.5	44%	9%	11%	17%	11%	7%
	Crisis: Lehman	1,945.8	38%	6%	10%	21%	18%	8%
	Crisis: After Dec 2008	4,749.0	70%	7%	7%	8%	5%	3%
Total CP	Before 2007	122,613.1	62%	6%	5%	14%	6%	6%
	Pre-crisis	167,143.0	68%	5%	4%	13%	4%	6%
	Crisis: Pre-Lehman	161,196.9	68%	7%	5%	10%	4%	6%
	Crisis: Lehman	158,015.5	71%	6%	4%	8%	4%	7%
	Crisis: After Dec 2008	91,499.4	65%	8%	4%	11%	4%	8%
Total CP(4)	Before 2007	63,629.1	59%	6%	5%	18%	7%	5%
	Pre-crisis	84,483.8	63%	5%	4%	16%	5%	6%
	Crisis: Pre-Lehman	88,866.0	66%	7%	5%	12%	4%	6%
	Crisis: Lehman	91,623.0	73%	6%	4%	8%	4%	6%
	Crisis: After Dec 2008	43,839.1	65%	7%	4%	13%	4%	7%

Table 6: Multiple Break Points for CP Issuance, Short/Long Ratio (30 day Rolling)

This table presents the common breakpoints for the short/long ratio of CP Issuance, which is defined as the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window). The short/long ratios hown are for four CP categories used to detect common breakpoints. Three breakpoints and the lower and upper bound of their 99% confidence intervals, as well as the number of securities, the data frequency and the sample period are reported.

Description	Number of Securities	Break Point	Lower bound	Upper bound	Frequency	Beginning	End
First Break	4	6/13/2007	6/12/2007	6/15/2007	Daily	10/3/2005	4/30/2009
Second Break	4	9/26/2008	9/26/2008	9/29/2008	Daily	10/3/2005	4/30/2009
Third Break	4	1/26/2009	1/23/2009	1/28/2009	Daily	10/3/2005	4/30/2009

Table 7: Multiple Break Points for CP Issuance Level

This table presents the common breakpoints for the issuance level of four CP categories. Three breakpoints and the lower and upper bound of their 99% confidence intervals, as well as the number of securities, the data frequency and the sample period for each maturity are reported.

Description	Breaks	Number of Securities	Break Point	Lower bound	Upper bound	Frequency	Beginning	End
Overnight	First	4	5/31/2007	5/30/2007	6/4/2007	Daily	10/3/2005	4/30/2009
	Second	4	9/19/2008	9/18/2008	9/23/2008	Daily	10/3/2005	4/30/2009
	Third	4	12/31/2008	12/31/2008	1/2/2009	Daily	10/3/2005	4/30/2009
One-month	First	4	9/24/2007	9/14/2007	10/3/2007	Daily	10/3/2005	4/30/2009
	Second	4	12/31/2007	12/6/2007	1/25/2008	Daily	10/3/2005	4/30/2009
	Third	4	9/12/2008	9/5/2008	9/22/2008	Daily	10/3/2005	4/30/2009
Three-month	First	4	3/8/2007	2/28/2007	3/19/2007	Daily	10/3/2005	4/30/2009
	Second	4	12/4/2007	11/16/2007	12/20/2007	Daily	10/3/2005	4/30/2009
	Third	4	9/16/2008	9/11/2008	9/22/2008	Daily	10/3/2005	4/30/2009

Table 8: Summary of the Spreads by Term to Maturity

This table reports the spreads for overnight, one month, and three-month maturities for the different money market instruments during different subperiods. The spread is defined as the difference between the promised contractual rate and the federal funds target rate. All spreads are adjusted for the seasonal effects by regressing spreads on the calendar dummies. Panel A shows spreads for Fed Funds, GC repo and LIBOR. Panel B presents spreads for four categories of commercial paper. Panel C reports spreads for six categories of repo. The subperiods are as follows: Pre-crisis : Jan. 1, 2007 to Jul. 22, 2007; Crisis: Pre-Lehman: Jul. 23, 2007 to Aug. 14, Aug 2008; Crisis: Lehman: Aug. 15, 2008 to Dec. 14, 2008; Crisis: After Dec 2008: Dec. 15, 2008 to Apr. 29, 2009. T-statistics for the null hypothesis spread=0 are reported in parentheses.

Panel A: Fed Funds, General Collateral Repo, LIBOR

Series	Periods	Overnight	One-month	Three-month
Fed Fund	Pre-crisis	-0.32	4.15	5.97
		(-1.54)	(37.44)	(49.51)
	Crisis: Pre-Lehman	-3.32	45.59	66.09
		(-2.44)	(22.37)	(33.17)
	Crisis: Lehman	-37.04	163.31	225.91
		(-6.00)	(10.13)	(14.44)
	Crisis: After Dec 2008	6.97	38.39	105.95
		(5.46)	(26.00)	(34.75)
GC	Pre-crisis	-3.83	-6.69	-6.80
		(-14.38)	(-27.59)	(-25.9)
	Crisis: Pre-Lehman	-23.27	-17.46	-17.38
		(-6.96)	(-8.86)	(-10.39)
	Crisis: Lehman	-56.32	2.06	9.57
		(-7.53)	(0.87)	(4.34)
	Crisis: After Dec 2008	11.02	6.78	8.83
		(6.76)	(9.36)	(14.00)
LIBOR	Pre-crisis	5.33	8.66	10.81
		(33.06)	(72.33)	(80.18)
	Crisis: Pre-Lehman	16.76	47.39	65.27
		(10.76)	(24.13)	(39.43)
	Crisis: Lehman	13.85	138.70	181.02
		(1.03)	(10.64)	(14.69)
	Crisis: After Dec 2008	13.37	23.75	97.43
		(7.55)	(22.39)	(50.67)

Panel B: Commercial Paper				
Series	Periods	Overnight	One-month	Three-month
A2/P2 Nonfinancial CP	Pre-crisis	8.97	16.41	18.54
		(24.46)	(36.20)	(28.27)
	Crisis: Pre-Lehman	47.52	77.10	89.60
		(28.27)	(31.11)	(36.19)
	Crisis: Lehman	172.89	351.97	361.65
		(11.53)	(13.12)	(8.94)
	Crisis: After Dec 2008	87.34	122.49	144.01
		(17.33)	(6.44)	(7.68)
AA Asset-backed CP	Pre-crisis	1.47	3.27	2.86
		(8.34)	(21.99)	(13.60)
	Crisis: Pre-Lehman	37.52	67.37	74.87
		(27.49)	(20.65)	(27.64)
	Crisis: Lehman	50.78	139.06	176.49
		(5.05)	(9.85)	(13.35)
	Crisis: After Dec 2008	38.40	40.08	66.32
		(16.13)	(21.98)	(8.84)
AA Financial CP	Pre-crisis	-1.51	-0.57	0.13
		(-8.65)	(-4.21)	(0.69)
	Crisis: Pre-Lehman	-5.90	26.27	51.52
		(-6.59)	(17.95)	(27.71)
	Crisis: Lehman	-35.51	88.39	135.27
		(-6.10)	(10.58)	(11.01)
	Crisis: After Dec 2008	7.30	17.58	46.38
		(4.83)	(14.03)	(6.81)
AA Nonfinancial CP	Pre-crisis	-1.90	-2.85	-0.08
		(-10.98)	(-15.72)	(-0.26)
	Crisis: Pre-Lehman	-3.01	7.01	11.71
		(-3.33)	(7.89)	(7.13)
	Crisis: Lehman	-36.53	16.94	76.08
		(-5.44)	(6.01)	(9.95)
	Crisis: After Dec 2008	7.73	1.46	12.25
		(4.75)	(1.72)	(7.32)

Panel C: Repo				
Series	Periods	Overnight	One-month	Three-month
<AA ABS-RMBS / CMBS	Pre-crisis	10.16	10.80	9.26
		(8.36)	(33.33)	(68.28)
	Crisis: Pre-Lehman	49.12	92.06	111.52
		(13.07)	(30.53)	(34.84)
	Crisis: Lehman	136.94	303.66	346.80
		(8.9)	(16.92)	(19.21)
	Crisis: After Dec 2008	207.36	238.79	312.30
		(74.21)	(147.24)	(172.87)
A-AAA ABS-Auto / CC / SL	Pre-crisis	3.23	4.82	4.26
		(3.07)	(15.87)	(31.35)
	Crisis: Pre-Lehman	30.07	73.58	91.23
		(8.51)	(27.47)	(34.20)
	Crisis: Lehman	83.06	219.67	266.07
		(5.09)	(13.34)	(16.50)
	Crisis: After Dec 2008	108.90	118.17	192.13
		(34.65)	(65.71)	(81.12)
AA-AAA ABS-RMBS / CMBS	Pre-crisis	5.16	6.80	6.26
		(4.24)	(20.99)	(46.16)
	Crisis: Pre-Lehman	37.96	81.95	102.20
		(10.65)	(29.26)	(35.29)
	Crisis: Lehman	110.39	277.03	320.17
		(7.01)	(15.91)	(18.31)
	Crisis: After Dec 2008	173.64	205.10	278.62
		(70.07)	(148.22)	(153.48)
AA-AAA CLO	Pre-crisis	5.16	6.80	6.26
		(4.24)	(20.99)	(46.16)
	Crisis: Pre-Lehman	45.75	89.22	113.12
		(11.8)	(27.21)	(33.84)
	Crisis: Lehman	125.99	292.47	335.23
		(8.38)	(15.83)	(17.99)
	Crisis: After Dec 2008	202.31	233.76	307.28
		(74.11)	(144.43)	(170.74)
AA-AAA Corporates	Pre-crisis	-0.82	-2.70	-2.24
		(-0.92)	(-11.39)	(-18.62)
	Crisis: Pre-Lehman	11.58	54.40	72.15
		(3.71)	(25.36)	(35.25)
	Crisis: Lehman	19.18	155.36	202.09
		(1.02)	(10.62)	(14.65)
	Crisis: After Dec 2008	21.65	31.09	105.05
		(8.73)	(23.48)	(51.83)
BBB+ / A Corporates	Pre-crisis	1.91	0.64	1.47
		(2.04)	(1.89)	(10.17)
	Crisis: Pre-Lehman	18.45	61.58	79.64
		(5.67)	(26.05)	(35.58)
	Crisis: Lehman	35.82	172.07	218.79
		(1.94)	(11.54)	(15.49)
	Crisis: After Dec 2008	37.11	46.40	120.36
		(13.14)	(35.63)	(53.5)

Table 9: The Term Structures of Spreads

This table presents different measures of the slope of the term structure of spreads at points on the term structure for the different money market instruments during different subperiods. 1m/1d is the difference between one-month and overnight spread. 3m/1d is the difference between three-month and overnight spread. 3m/1m is the difference between three-month and overnight spread. All slopes are adjusted for seasonal effects. Panel A shows slopes for Fed Funds, GC repo and LIBOR. Panel B presents slopes for four categories of commercial paper. Panel C reports slopes for six categories of repo. The subperiods are as follows: Pre-crisis : Jan. 1, 2007 to Jul. 22, 2007; Crisis: Pre-Lehman: Jul. 23, 2007 to Aug. 14, Aug 2008; Crisis: Lehman: Aug. 15, 2008 to Dec. 14, 2008; Crisis: After Dec 2008: Dec. 15, 2008 to Apr. 29, 2009. T-statistics for the null hypothesis slope=0 are reported in parentheses.

Panel A: Fed Funds, General Collateral Repo, LIBOR

Series	Periods	1m/1d	3m/1d	3m/1m
Fed Fund	Pre-crisis	4.46	6.28	1.82
		(18.45)	(25.30)	(23.81)
	Crisis: Pre-Lehman	48.91	69.41	20.50
		(19.53)	(29.39)	(19.72)
	Crisis: Lehman	200.36	262.96	62.60
		(10.87)	(13.82)	(10.77)
	Crisis: After Dec 2008	31.22	98.97	67.57
		(12.27)	(25.49)	(23.65)
GC	Pre-crisis	-2.87	-2.99	-0.12
		(-10.14)	(-9.97)	(-0.76)
	Crisis: Pre-Lehman	5.81	5.89	0.07
		(2.71)	(2.30)	(0.09)
	Crisis: Lehman	59.33	64.9	6.12
		(8.62)	(8.74)	(5.26)
	Crisis: After Dec 2008	-4.23	-2.19	2.04
		(-2.67)	(-1.43)	(4.72)
LIBOR	Pre-crisis	3.31	5.45	2.14
		(17.23)	(27.19)	(28.61)
	Crisis: Pre-Lehman	30.65	48.42	17.87
		(13.19)	(23.24)	(18.62)
	Crisis: Lehman	124.80	167.00	42.31
		(8.25)	(10.75)	(15.26)
	Crisis: After Dec 2008	10.45	84.10	73.68
		(4.53)	(25.48)	(47.45)

Panel B: Commercial Paper				
Series	Periods	1m/1d	3m/1d	3m/1m
A2/P2 Nonfinancial	Pre-crisis	7.42	9.37	1.92
		(23.53)	(18.21)	(5.23)
	Crisis: Pre-Lehman	29.57	41.36	12.94
		(12.72)	(18.5)	(9.04)
	Crisis: Lehman	179.08	200.91	35.16
		(9.31)	(7.31)	(3.20)
	Crisis: After Dec 2008	35.14	50.39	9.76
		(2.26)	(3.16)	(0.78)
AA Asset-backed	Pre-crisis	1.79	1.38	-0.40
		(9.10)	(5.54)	(-3.13)
	Crisis: Pre-Lehman	29.85	37.40	7.40
		(10.35)	(16.26)	(5.41)
	Crisis: Lehman	88.27	125.70	37.42
		(8.14)	(10.58)	(5.07)
	Crisis: After Dec 2008	2.15	28.39	26.24
		(0.92)	(4.19)	(3.52)
AA Financial	Pre-crisis	0.94	1.67	0.70
		(4.64)	(7.04)	(5.54)
	Crisis: Pre-Lehman	32.18	57.43	25.24
		(17.69)	(26.67)	(19.44)
	Crisis: Lehman	122.77	154.72	39.58
		(11.64)	(10.38)	(5.56)
	Crisis: After Dec 2008	10.27	40.05	29.41
		(5.84)	(5.90)	(4.25)
AA Nonfinancial	Pre-crisis	-0.96	1.71	1.31
		(-4.12)	(4.72)	(6.55)
	Crisis: Pre-Lehman	10.05	15.27	3.50
		(7.59)	(6.91)	(2.99)
	Crisis: Lehman	52.27	113.83	56.95
		(6.34)	(7.82)	(8.39)
	Crisis: After Dec 2008	-5.11	6.54	12.45
		(-4.58)	(4.00)	(6.84)

Panel C: Repo				
Series	Periods	1m/1d	3m/1d	3m/1m
<AA ABS-RMBS / CMBS	Pre-crisis	0.63	-0.90	-1.54
		(0.63)	(-0.76)	(-5.70)
	Crisis: Pre-Lehman	42.84	62.23	19.45
		(11.57)	(17.20)	(14.65)
	Crisis: Lehman	165.75	209.16	43.14
		(5.51)	(6.89)	(15.98)
	Crisis: After Dec 2008	31.51	104.99	73.51
		(13.12)	(33.18)	(51.18)
A-AAA ABS-Auto / CC / SL	Pre-crisis	1.57	1.02	-0.55
		(1.78)	(0.99)	(-2.24)
	Crisis: Pre-Lehman	43.53	61.01	17.65
		(11.73)	(16.83)	(16.33)
	Crisis: Lehman	136.2	182.73	46.39
		(4.75)	(6.30)	(14.90)
	Crisis: After Dec 2008	9.35	83.26	73.96
		(3.04)	(23.5)	(41.92)
AA-AAA ABS-RMBS / CMBS	Pre-crisis	1.63	1.09	-0.54
		(1.62)	(0.92)	(-2.00)
	Crisis: Pre-Lehman	43.92	64.10	20.25
		(11.83)	(17.77)	(15.78)
	Crisis: Lehman	165.75	209.16	43.14
		(5.51)	(6.89)	(15.98)
	Crisis: After Dec 2008	31.53	105.02	73.51
		(13.40)	(33.30)	(50.53)
AA-AAA CLO	Pre-crisis	1.63	1.09	-0.54
		(1.62)	(0.92)	(-2.00)
	Crisis: Pre-Lehman	43.27	67.11	23.89
		(11.56)	(18.23)	(16.46)
	Crisis: Lehman	165.37	208.40	42.76
		(5.53)	(6.90)	(15.73)
	Crisis: After Dec 2008	31.53	105.02	73.51
		(13.40)	(33.30)	(50.53)
AA-AAA Corporates	Pre-crisis	-1.87	-1.42	0.45
		(-2.34)	(-1.67)	(2.49)
	Crisis: Pre-Lehman	42.81	60.41	17.75
		(11.65)	(16.83)	(17.14)
	Crisis: Lehman	136.2	183.06	46.72
		(4.75)	(6.33)	(15.04)
	Crisis: After Dec 2008	9.49	83.40	73.95
		(3.30)	(24.62)	(39.02)
BBB+ / A Corporates	Pre-crisis	-1.27	-0.44	0.83
		(-1.52)	(-0.48)	(2.97)
	Crisis: Pre-Lehman	43.14	61.02	18.05
		(11.70)	(16.99)	(17.34)
	Crisis: Lehman	136.2	183.06	46.72
		(4.75)	(6.33)	(15.04)
	Crisis: After Dec 2008	9.35	83.26	73.96
		(3.04)	(23.50)	(41.92)

Table 10: Multiple Break Points for Slopes

This table presents the common breakpoints for the slope of the term structure of spreads. Slopes are the difference between one-month and overnight spread. Three breakpoints and the lower and upper bound of their 99% confidence intervals, as well as the number of securities, the data frequency and the sample period for each group are reported.

Description	Breaks	Number of Securities	Break Point	Lower bound	Upper bound	Frequency	Beginning	End
CP, Fed Fund, GC, LIBOR, Repo	First	13	7/23/2007	7/23/2007	7/24/2007	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR, Repo	Second	13	8/14/2008	8/14/2008	8/15/2008	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR, Repo	Third	13	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR	First	7	8/8/2007	8/8/2007	8/9/2007	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR	Second	7	9/12/2008	9/12/2008	9/16/2008	Daily	10/3/2005	4/30/2009
CP, Fed Fund, GC, LIBOR	Third	7	12/15/2008	12/15/2008	12/16/2008	Daily	10/3/2005	4/30/2009
Repo	First	6	7/23/2007	7/20/2007	7/25/2007	Daily	10/3/2005	4/30/2009
Repo	Second	6	8/14/2008	8/14/2008	8/15/2008	Daily	10/3/2005	4/30/2009
Repo	Third	6	12/15/2008	12/12/2008	12/17/2008	Daily	10/3/2005	4/30/2009

Table 11: Changes in Short-term Ratings for Financial Firms during the Crisis

This table reports the changes in S&P short-term credit ratings for financial firms during the crisis of 2007-2009. Financial firms are defined as the firms with SIC code from 6000 to 6999. To be included in the sample, the firms must have an S&P short-term credit rating before June 30th 2007. The first two columns present the number of firms for different ratings on June 30th 2007. The third to eighth column shows the number of firms for different ratings on June 30th 2009. The transition probabilities are presented in parentheses.

	Total	A-1+	A-1	A-2	A-3	B	C	D	No Rating
A-1+	48	29	19						
		(0.60)	(0.39)						
A-1	60	4	36	14	1	3			2
		(0.06)	(0.60)	(0.23)	(0.01)	(0.05)			(0.03)
A-2	46		3	30	4	5			4
			(0.06)	(0.65)	(0.08)	(0.10)			(0.08)
A-3	13			1	8	3			1
				(0.07)	(0.61)	(0.23)			(0.07)
B	8				1	3	2		2
					(0.12)	(0.37)	(0.25)		(0.25)
D	1							1	
								(1.00)	

Table 12: The Liability Structure of Financial Firms: 2007 to 2008

This table reports the aggregated debt structure for financial commercial paper issuers from 2007 to 2008. To identify the financial commercial paper issuers, we first get the list of firms which have received short-term credit ratings from Moody's or Standard & Poor's before 2007. Then we restrict our attention only to financial firms and identify 229 financial firms that have short-term ratings. The debt data is from Capital IQ. We are able to find the debt data for 77 of these 229 financial firms. And 13 of the 77 firms have never issued any commercial paper since 2001. So the final sample includes 64 financial firms, which cover most important commercial banks, investment banks and insurance firms in U.S.

(in millions)	2007		2008	
Total Debts	6,558,396	100.00%	5,670,953	100.00%
Total Commercial Paper	564,364	8.60%	421,032	7.40%
Total Revolving Credit	65,221	1.00%	138,133	2.40%
Total Senior Bonds and Notes	2,818,906	43.00%	2,551,541	45.00%
Total Subordinated Bonds and Notes	225,657	3.40%	271,893	4.80%
Total Term Loans	212,892	3.20%	400,264	7.10%
Total Trust Preferred	102,538	1.60%	119,890	2.10%
Total Capital Leases	2,582	0.00%	2,611	0.00%
Other Borrowings	2,577,771	39.30%	1,772,505	31.30%

Table 13: Breaks in Repo Haircuts

This table presents the common breakpoints for repo haircuts. Three breakpoints and the lower and upper bound of their 99% confidence intervals are reported.

	Break point	Lower bound	Upper bound
First Break	2007/10/23	2007/10/23	2007/10/24
Second Break	2008/2/6	2008/2/6	2008/2/7
Third Break	2008/9/15	2008/9/15	2008/9/16

Table 14: Breaks in Financial CDS

This table presents the common breakpoints for financial CDS. Four breakpoints and the lower and upper bound of their 99% confidence intervals are reported. The data used is daily data on the nine financial firms listed in Table 1; Lehman is excluded. The data series start January 1, 2007-December 31, 2009.

	Break point	Lower bound	Upper bound
First Break	7/16/2007	7/16/2007	7/17/2007
Second Break	2/8/2008	2/8/2008	2/13/2008
Third Break	6/26/2008	6/26/2008	6/27/2008
Fourth Break	9/11/2008	9/11/2008	9/12/2008

Table B1: Overnight Spreads, Before the Crisis

This table presents the seasonal effects of overnight spreads for money market instruments before the crisis. The coefficients of regressions of spreads on calendar dummies are presented. T-statistics are reported in parentheses.

	Intercept	Quarter-end, Day (-15,-11)	Quarter-end, Day (-10,-6)	Quarter-end, Day (-5,-1)	Quarter-end, Day (0,1)	Quarter-end, Day (2,5)	Calendar Day, 1st	Calendar Day, 15th	Calendar Day, 30th or 31th	Monday	Friday
Fed Fund	-0.32	0.64	-0.02	1.76	6.56	0.19	2.75	5.88	4.99	2.48	0.16
	(-1.54)	(0.99)	(-0.03)	(2.83)	(5.88)	(0.27)	(3.09)	(7.20)	(6.06)	(6.46)	(0.44)
GC	-3.83	0.84	-2.42	-1.58	-2.10	0.24	4.30	6.83	4.69	2.20	-0.61
	(-14.38)	(1.02)	(-2.97)	(-1.98)	(-1.48)	(0.27)	(3.80)	(6.59)	(4.49)	(4.52)	(-1.29)
LIBOR	5.33	0.53	-0.36	4.16	12.76	1.22	1.19	5.92	6.61	1.57	-0.17
	(33.06)	(1.06)	(-0.72)	(8.26)	(14.73)	(2.19)	(1.71)	(9.46)	(10.25)	(5.13)	(-0.60)
A2/P2 Nonfinancial	8.97	1.24	-0.26	6.11	10.63	2.56	1.91	6.99	6.31	2.50	0.92
	(24.46)	(1.10)	(-0.23)	(5.60)	(5.45)	(2.04)	(1.22)	(4.90)	(4.34)	(3.68)	(1.42)
AA Asset-backed	1.47	1.07	-0.32	4.80	9.34	1.70	2.95	7.31	6.65	2.37	0.33
	(8.34)	(1.97)	(-0.60)	(9.15)	(9.84)	(2.82)	(3.92)	(10.65)	(9.50)	(7.25)	(1.06)
AA Financial	-1.51	0.56	-1.61	3.42	8.07	1.73	3.15	6.96	6.46	2.51	-0.25
	(-8.65)	(1.03)	(-3.01)	(6.57)	(8.66)	(2.88)	(4.23)	(10.20)	(9.29)	(7.72)	(-0.82)
AA Nonfinancial	-1.90	1.12	-0.27	4.67	6.99	1.64	3.33	7.09	6.55	2.53	0.34
	(-10.98)	(2.10)	(-0.50)	(9.10)	(7.62)	(2.77)	(4.55)	(10.56)	(9.57)	(7.93)	(1.13)
<AA ABS-RMBS / CMBS	10.16	1.30	13.52	67.80	77.07	-1.12	-2.64	-0.29	2.28	-1.96	5.88
	(8.36)	(0.32)	(3.45)	(19.80)	(6.11)	(-0.31)	(-0.52)	(-0.06)	(0.51)	(-0.85)	(2.71)
A-AAA ABS-Auto / CC / SL	3.23	0.63	10.97	54.64	71.28	-1.28	-2.53	-0.09	2.06	-1.43	5.10
	(3.07)	(0.18)	(3.24)	(18.46)	(6.54)	(-0.41)	(-0.58)	(-0.02)	(0.54)	(-0.72)	(2.72)
AA-AAA ABS-RMBS / CMBS	5.16	1.30	13.52	67.80	77.07	-1.12	-2.64	-0.29	2.28	-1.96	5.88
	(4.24)	(0.32)	(3.45)	(19.8)	(6.11)	(-0.31)	(-0.52)	(-0.06)	(0.51)	(-0.85)	(2.71)
AA-AAA CLO	5.16	1.30	13.52	67.80	77.07	-1.12	-2.64	-0.29	2.28	-1.96	5.88
	(4.24)	(0.32)	(3.45)	(19.80)	(6.11)	(-0.31)	(-0.52)	(-0.06)	(0.51)	(-0.85)	(2.71)
AA-AAA Corporates	-0.82	1.57	8.56	37.64	25.98	-1.66	-2.24	0.16	1.55	-1.08	2.46
	(-0.92)	(0.53)	(2.96)	(14.88)	(2.79)	(-0.62)	(-0.60)	(0.04)	(0.47)	(-0.63)	(1.54)
BBB+ / A Corporates	1.91	2.00	10.78	56.46	48.69	-1.46	-2.65	0.20	2.17	-1.92	4.02
	(2.04)	(0.64)	(3.58)	(21.43)	(5.02)	(-0.52)	(-0.68)	(0.05)	(0.64)	(-1.09)	(2.41)

Table B2: Intercept Comparison

This table presents the spreads money market instruments controlling for different effects. The first column reports the results without any control. The second column reports the intercept from a regression of spreads on date dummies. For the following three columns, the intercept is adjusted for these variables by estimating the coefficient on the variable and then adding or subtracting the coefficient times the average of that variable. The third columns uses the average tax flow of all days, and the fourth columns uses the average tax flow of normal days, excluding quarter-end, beginning, middle and end of each month. The second average tax flow is smaller than the first one. The last column includes U.S. commercial banks' excess reserves. The sample period is from Jan. 1, 2001 to Jul. 22, 2007, the first breakpoint in repo.

	No Control	Date Dummies	Tax, all days average	Tax, Normal days	Excess Reserve, Normal days
Fed Fund	0.89	-0.32	0.89	0.66	0.80
GC	-3.24	-3.83	-3.22	-3.43	-3.03
LIBOR	6.56	5.33	6.56	6.34	6.32
A2/P2 Nonfinancial	10.86	8.97	10.84	10.60	10.53
AA Asset-backed	3.10	1.47	3.09	2.80	2.84
AA Financial	-0.20	-1.51	-0.22	-0.48	-0.41
AA Nonfinancial	-0.28	-1.90	-0.30	-0.58	-0.52
<AA ABS-RMBS / CMBS	16.44	10.16	16.49	16.53	13.88
A-AAA ABS-Auto / CC / SL	8.40	3.23	8.44	8.45	6.41
AA-AAA ABS-RMBS / CMBS	11.44	5.16	11.49	11.53	8.88
AA-AAA CLO	11.44	5.16	11.49	11.53	8.88
AA-AAA Corporates	2.45	-0.82	2.51	2.62	1.01
BBB+ / A Corporates	6.84	1.91	6.92	6.99	4.73

Table C1: Breakpoint Ordering

This table presents the order of break points obtaining from Bai's (2010) procedure. Algorithm Order is the order of breakpoints identified using Bai's procedure. They are not necessarily consistent with the breakpoints' chronological order. The lower and upper bound of breakpoints' 99% confidence intervals are also reported.

Panel A: Spreads				
CP, Fed Fund, GC, LIBOR, Repo				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	7/23/2007	7/23/2007	7/24/2007
2	2	8/14/2008	8/14/2008	8/15/2008
3	4	12/15/2008	12/15/2008	12/16/2008
CP, Fed Fund, GC, LIBOR				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/8/2007	8/8/2007	8/9/2007
2	2	9/12/2008	9/12/2008	9/16/2008
3	4	12/15/2008	12/15/2008	12/16/2008
Repo				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	2	7/23/2007	7/20/2007	7/25/2007
4	3	8/14/2008	8/14/2008	8/15/2008
3	4	12/15/2008	12/12/2008	12/17/2008
All CP				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	7/27/2007	7/26/2007	7/31/2007
2	2	9/12/2008	9/11/2008	9/17/2008
3	4	12/15/2008	12/15/2008	12/16/2008
Unsecured (Excluding ABCP)				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/6/2007	8/3/2007	8/8/2007
2	2	9/12/2008	9/11/2008	9/17/2008
3	4	12/15/2008	12/15/2008	12/16/2008
ABCP				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	7/27/2007	7/20/2007	8/6/2007
2	2	9/12/2008	9/5/2008	10/3/2008
3	4	10/16/2008	10/16/2008	10/17/2008
GC				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	2	8/13/2007	8/1/2007	8/24/2007
4	3	9/12/2008	9/4/2008	10/6/2008
2	4	12/15/2008	12/1/2008	1/12/2009

Panel B: Haircuts				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	2007/10/23	2007/10/23	2007/10/24
3	2	2008/2/6	2008/2/6	2008/2/7
4	3	2008/6/30	2008/6/30	2008/7/1
2	4	2008/9/15	2008/9/15	2008/9/16

Panel C: 1 Month/ Overnight Spread Slopes				
Panel A: Spreads				
CP, Fed Fund, GC, LIBOR, Repo				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	7/23/2007	7/24/2007	7/23/2007
2	2	8/15/2008	8/18/2008	8/15/2008
3	4	12/19/2008	1/2/2009	12/19/2008
CP, Fed Fund, GC, LIBOR				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/8/2007	8/9/2007	8/8/2007
2	2	9/12/2008	9/16/2008	9/12/2008
3	4	12/19/2008	1/2/2009	12/19/2008
Repo				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	7/23/2007	7/25/2007	7/20/2007
3	2	8/14/2008	8/15/2008	8/14/2008
2	4	12/17/2008	1/5/2009	12/11/2008
All CP				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/8/2007	8/10/2007	8/7/2007
2	2	9/12/2008	9/17/2008	9/11/2008
3	4	12/19/2008	1/2/2009	12/19/2008
Unsecured (Excluding ABCP)				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/8/2007	8/10/2007	8/7/2007
2	2	9/12/2008	9/16/2008	9/12/2008
3	4	12/19/2008	1/2/2009	12/19/2008
ABCP				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/9/2007	8/20/2007	8/1/2007
3	2	9/12/2008	9/18/2008	9/10/2008
2	4	1/2/2009	1/27/2009	11/25/2008
GC				
Algorithm Order	Chronological Order	Breakpoint	Lower Bound	Upper Bound
1	1	8/10/2007	8/23/2007	7/31/2007
3	2	9/12/2008	9/17/2008	9/11/2008
2	4	12/18/2008	1/27/2009	11/19/2008

Figure 1: Money Market Spreads Before and During the Crisis (bps)

This figure shows average seasonal adjusted overnight spreads for money market spreads for two periods. Before and during the crisis are distinguished by July 23, 2007, the first break we find in the repo spreads.

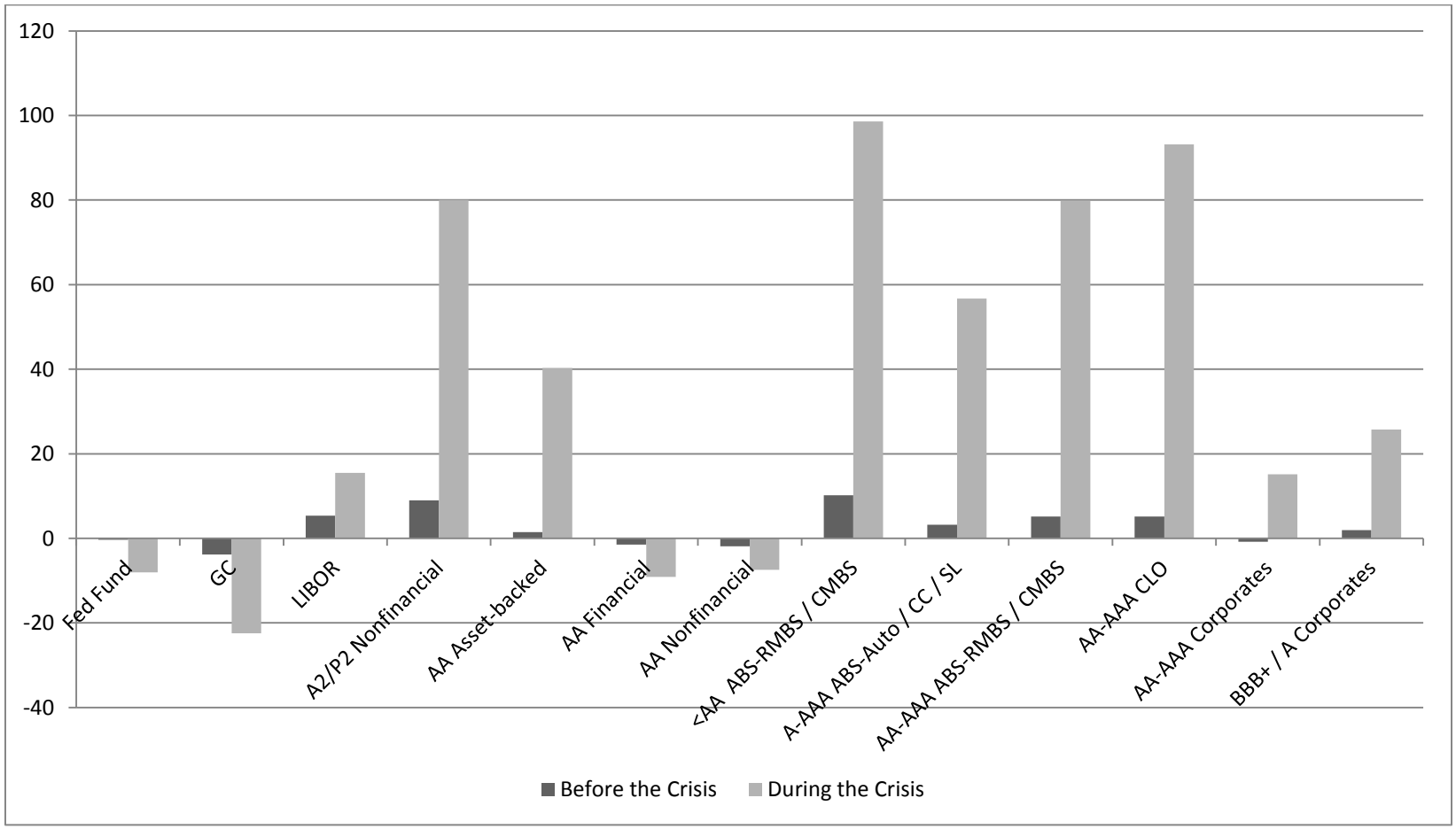


Figure 2: Short/Long Issuance Ratio, AA Asset-backed

This figure shows the short/long issuance ratio for AA asset-backed commerical paper. The ratio is defined as the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window).

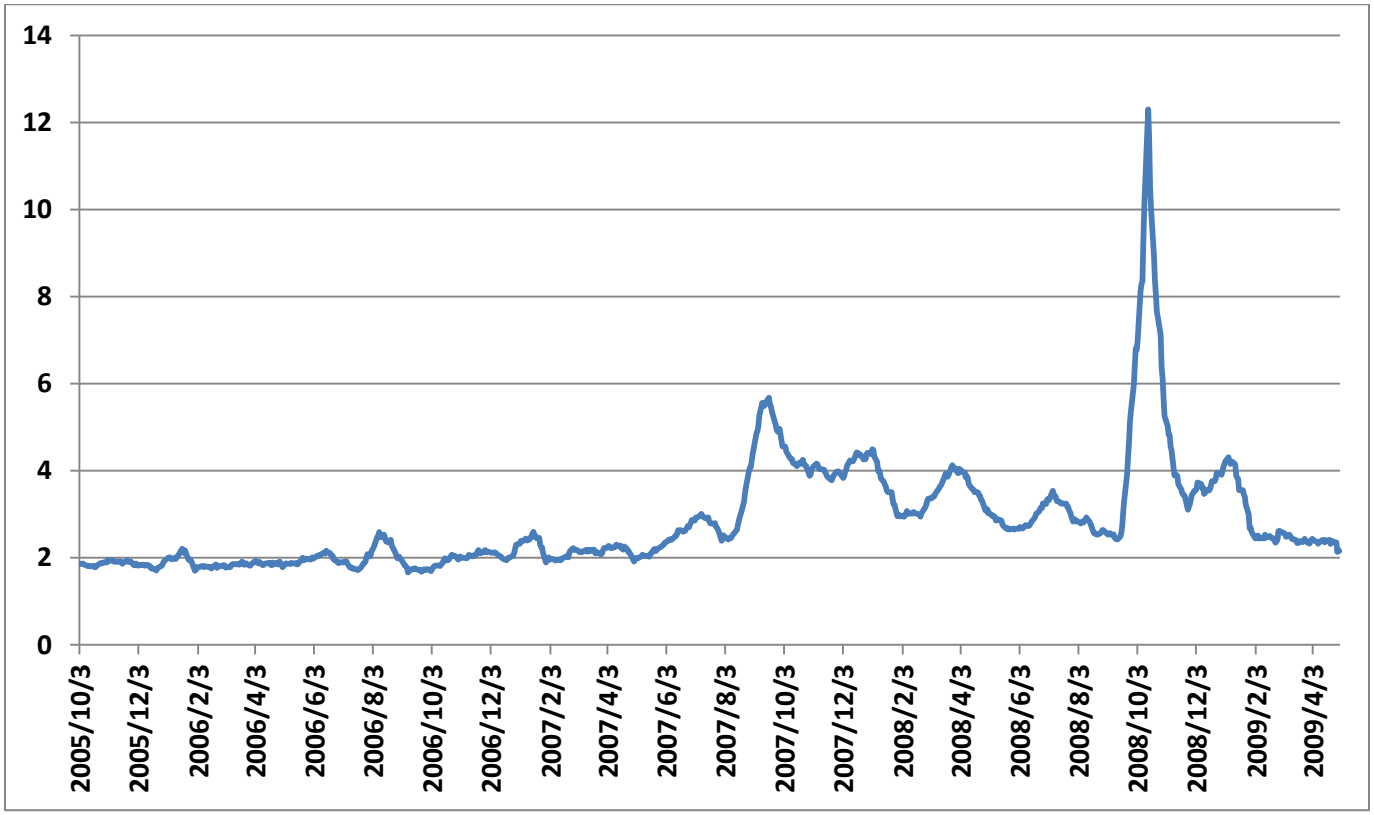


Figure 3: LIBOR Spread Term Structures (bps)

This figure shows the term structure of LIBOR spreads at three different points in time during the crsis.

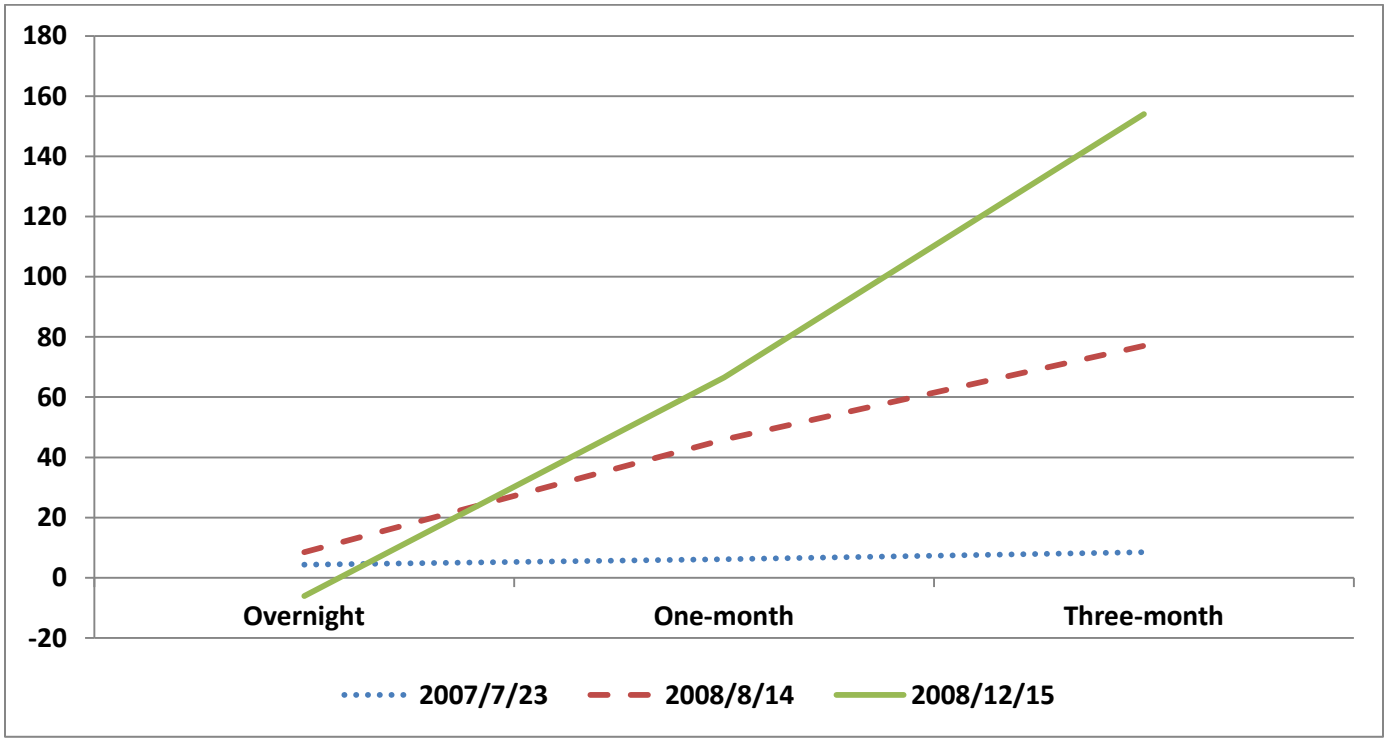


Figure 4: Crisis Phases

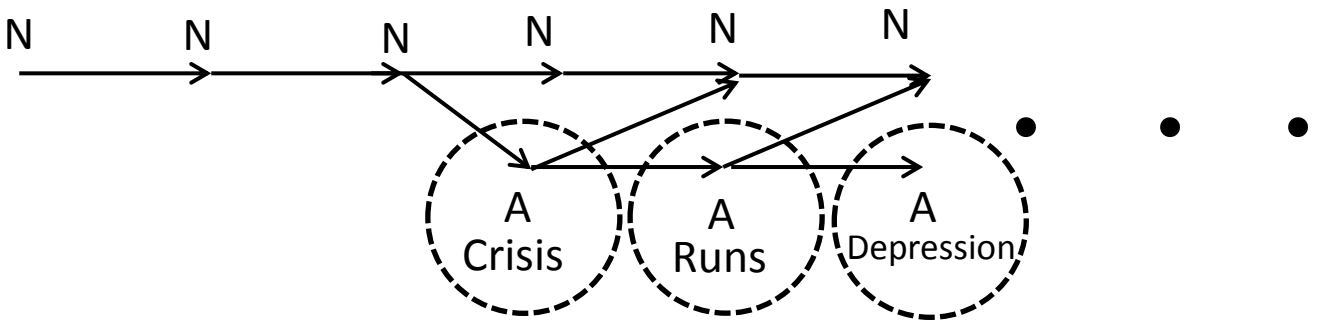


Figure 5: Money Market Spreads

This figure shows the spreads adjusted for the seasonal effects for money market instruments. The two vertical lines in the figure correspond to two of the breaks in the set of repo spreads.

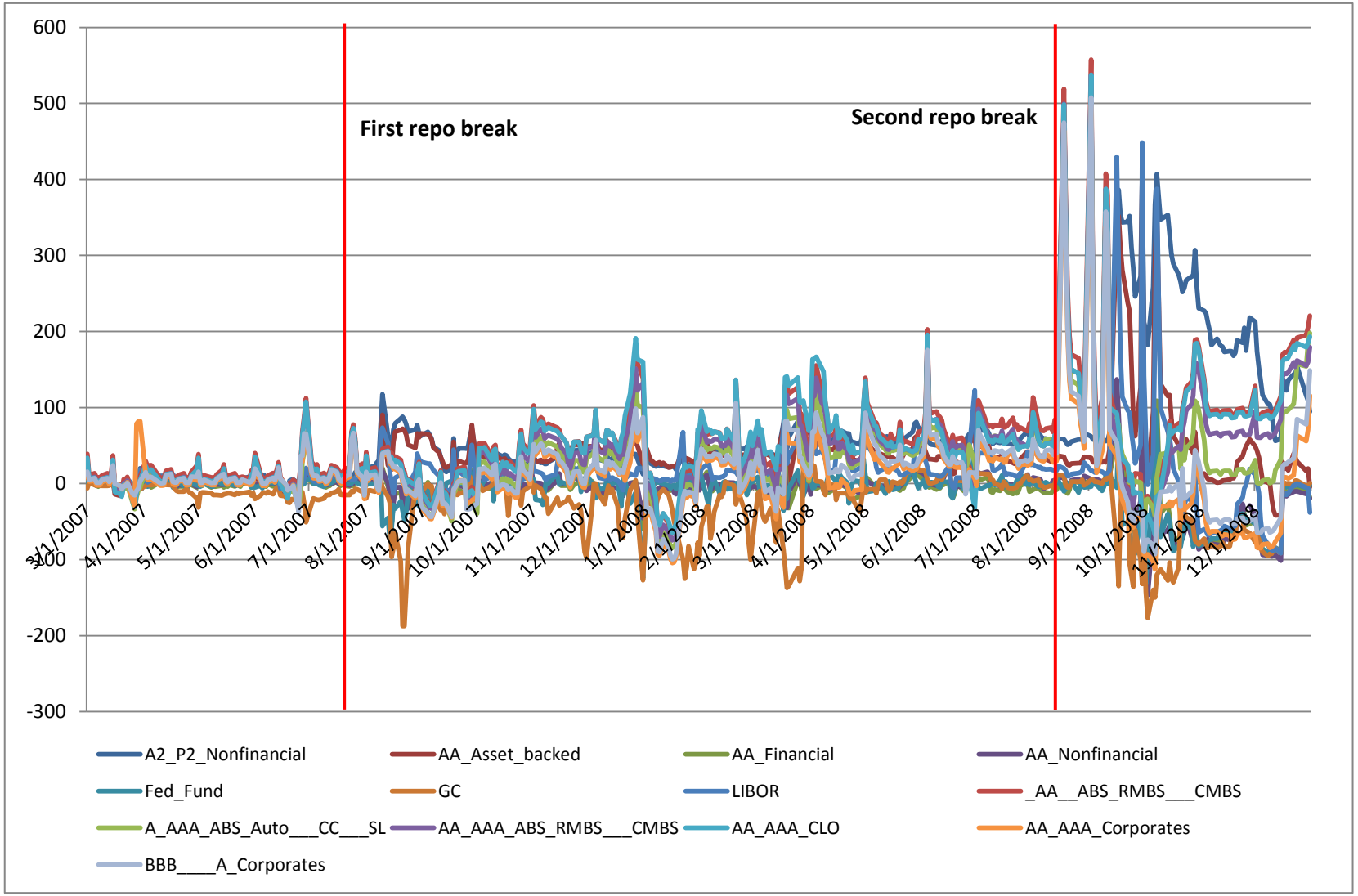


Figure 6: Money Markets Crisis Chronology for Spreads

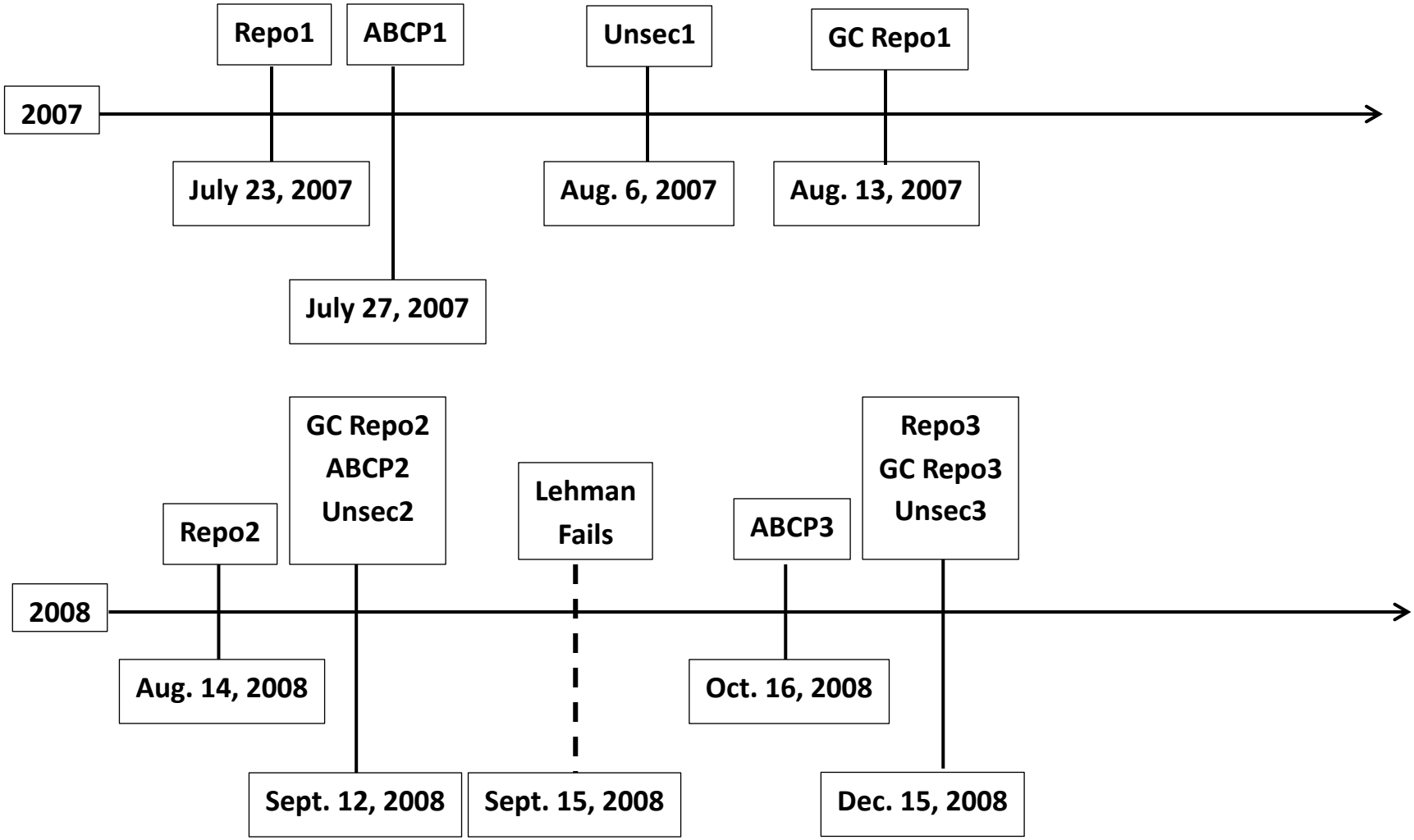


Figure 7: CP 1-4 Day Maturity Issuance by ABCP Conduits and AA Financial Firms, as a percentage of average issuance

This figure shows short-term (1-4 day) AA asset-backed and AA financial commercial paper issuance as a percentage of their total issuance

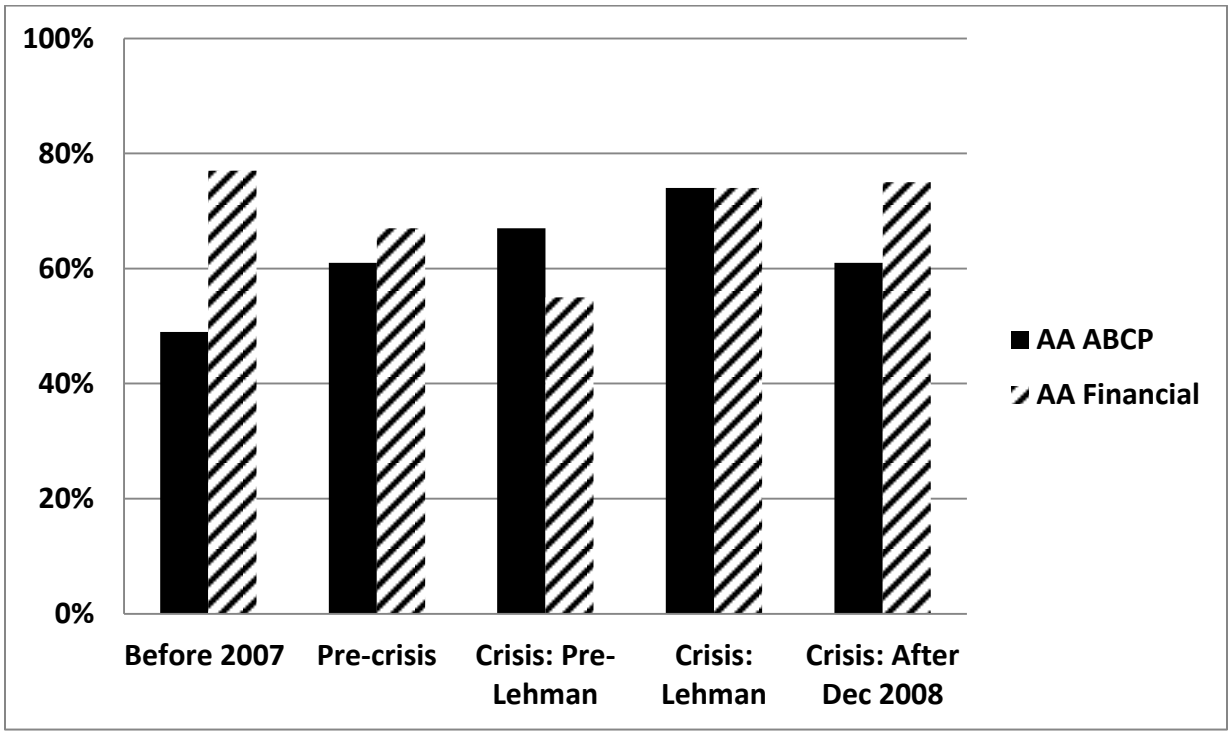
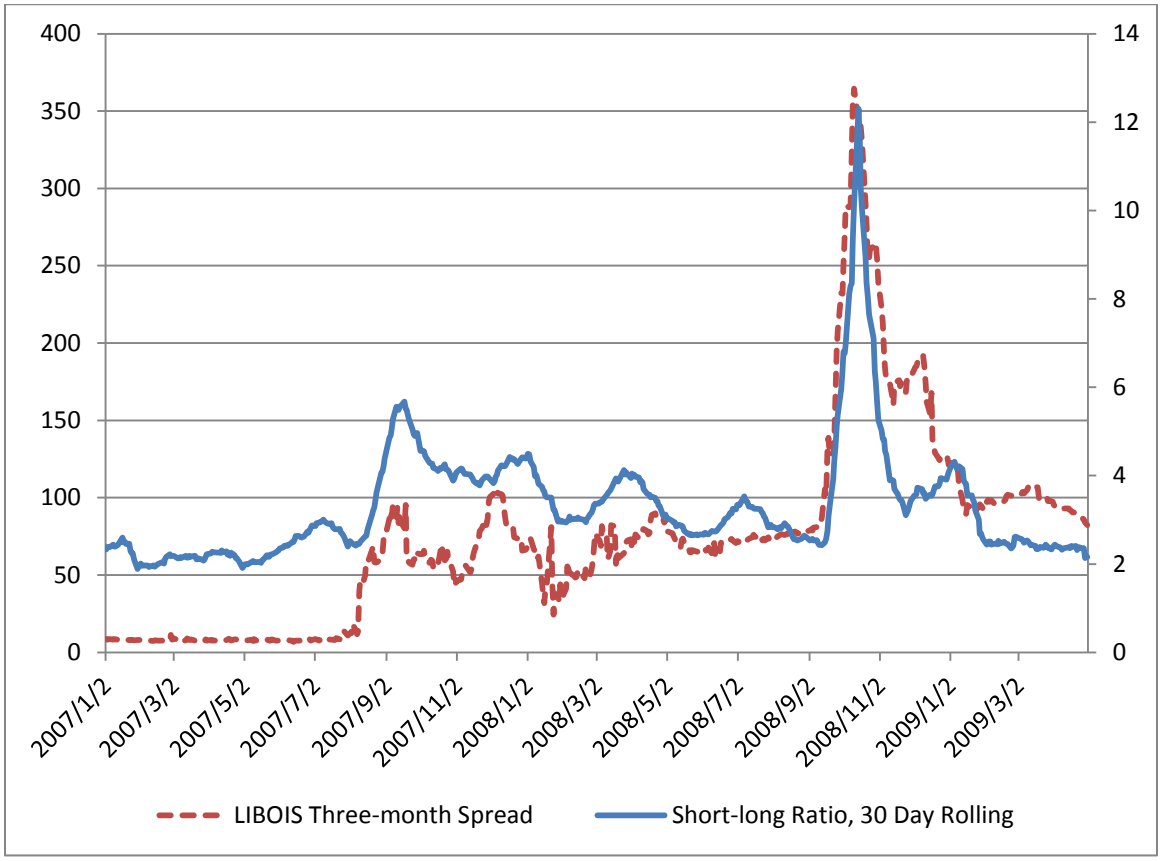


Figure 8: Counterparty Risk (bps) and CP Maturities

This figure plots the LIBIR minus overnight index swap three month spread and the short/long issuance ratio for AA asset-backed commerical paper. The ratio is defined as the ratio of the amount of CP issued with a maturity of less than 20 days (over a 30 day window) divided by the amount of CP issued with a maturity of 20 days or greater (over a 30 day window)



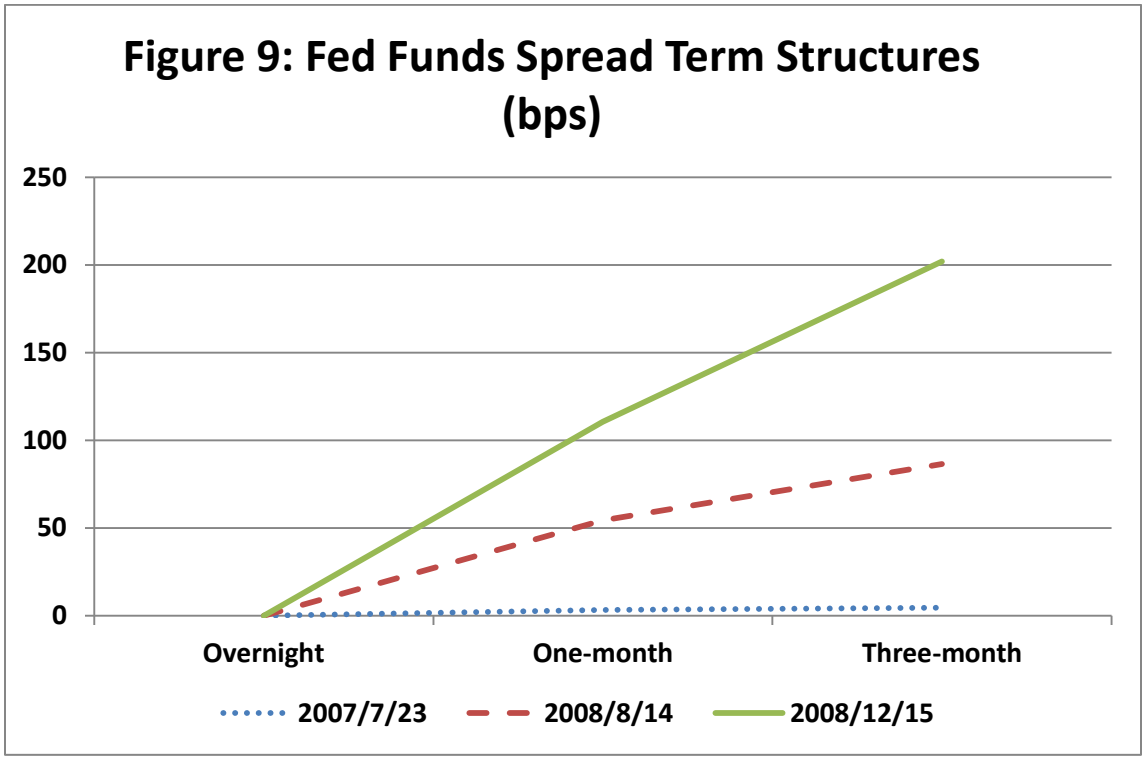


Figure 9: Fed Funds Spread Term Structures (bps)
250
200
150
100
50
0
Overnight
One-month
Three-month
2007/7/23
2008/8/14
2008/12/15

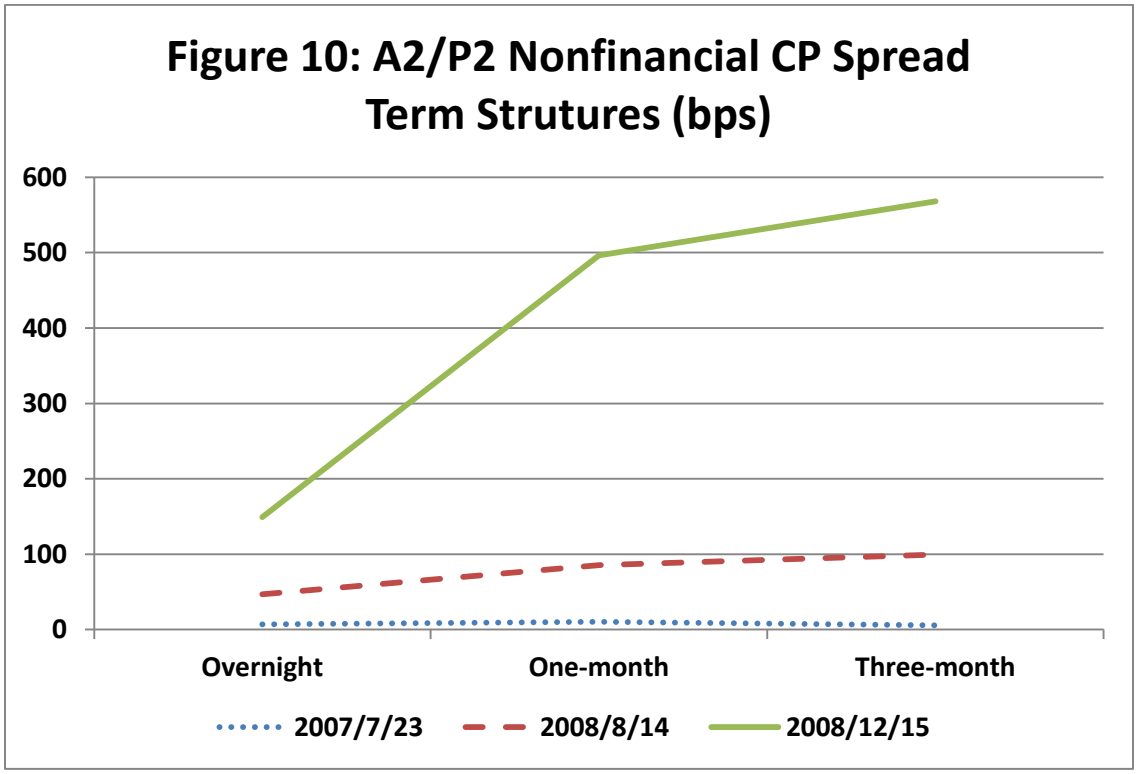


Figure 10: A2/P2 Nonfinancial CP Spread Term Strutures (bps)
600
500
400
300
200
100
0
Overnight
One-month
Three-month
2007/7/23
2008/8/14
2008/12/15

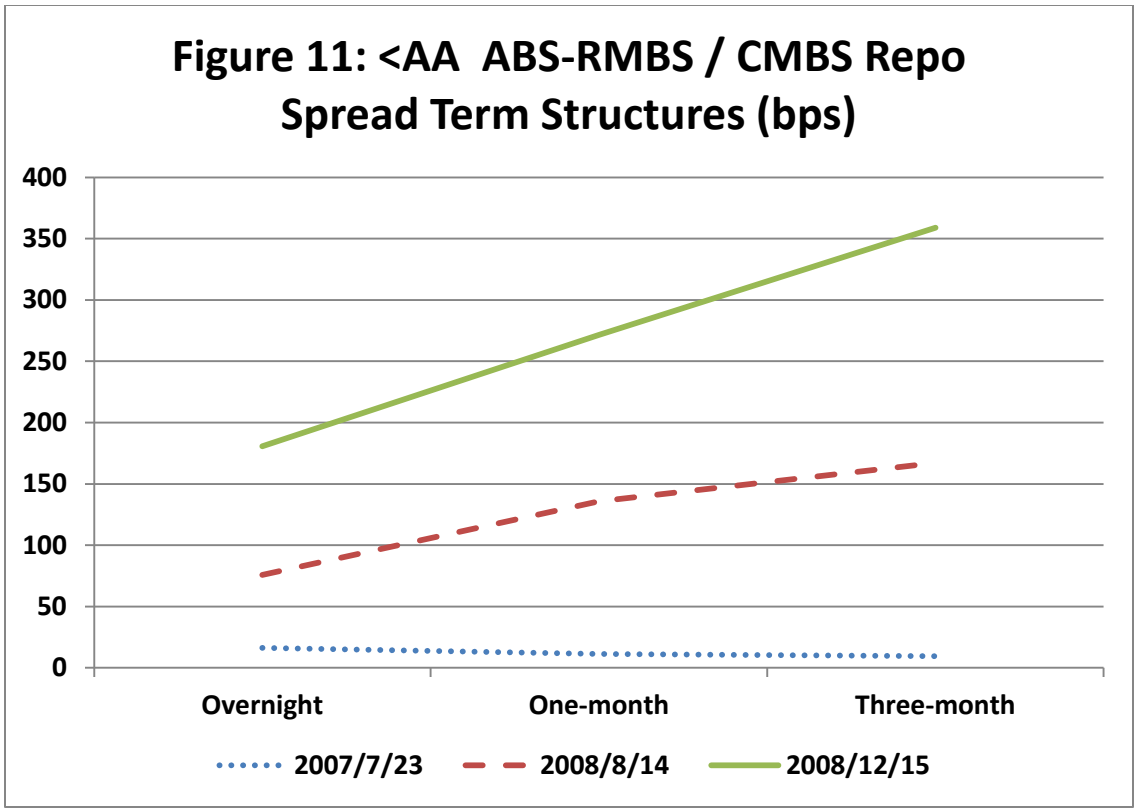
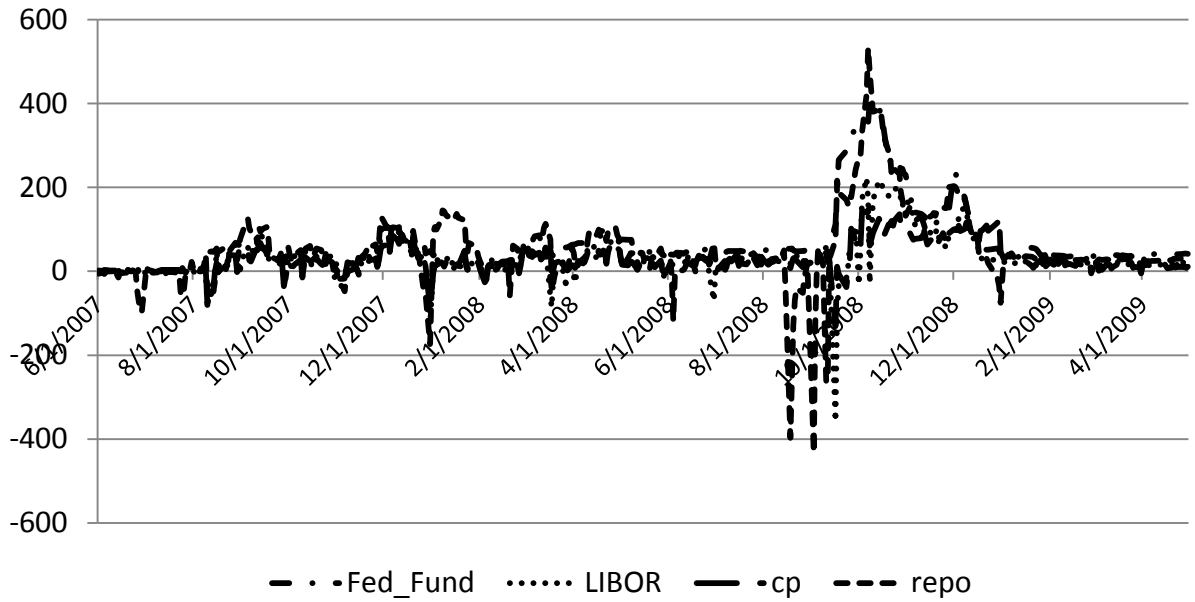


Figure 11: <AA ABS-RMBS / CMBS Repo Spread Term Structures (bps)
400
350
300
250
200
150
100
50
0
Overnight
One-month
Three-month
2007/7/23
2008/8/14
2008/12/15

Figure 12: Panel A: 1m/1d slope series, 20 day moving-average



Panel B: 1m/1d slope series, 20 day moving-average

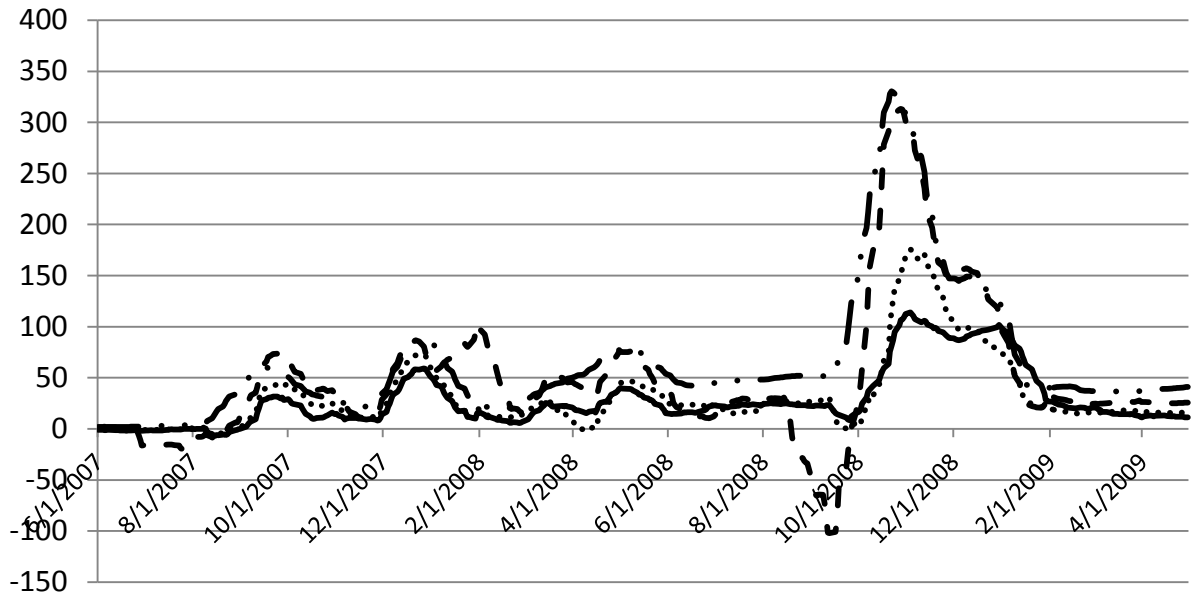


Figure 13: Crisis Chronology

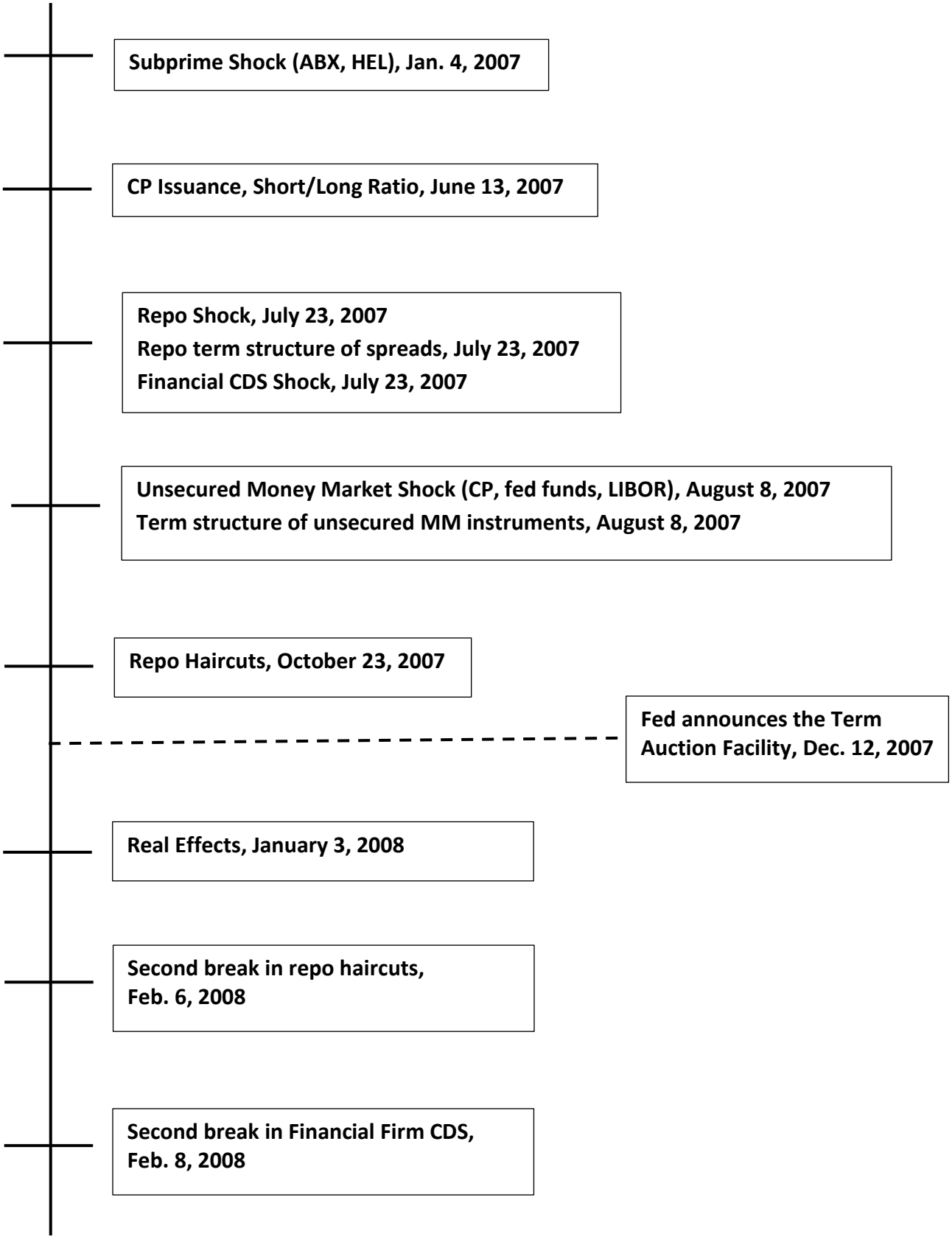


Figure 13: Crisis Chronology continued

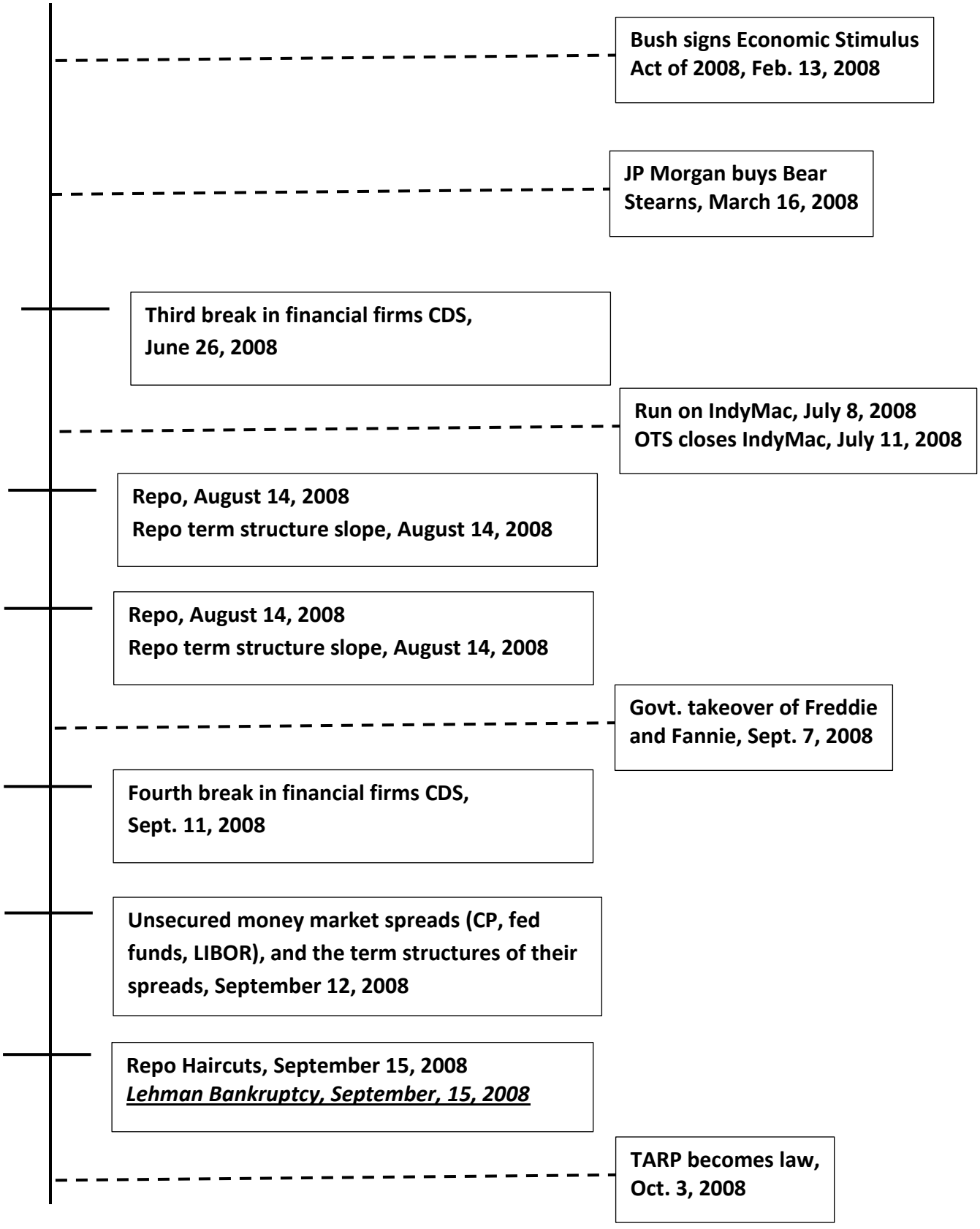


Figure B1: Bai Algorithm Ordering and Chronological Order