Sizing Up Repo *

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ABSTRACT

We measure the repo funding extended by money market funds and securities lenders to the shadow banking system, including quantities, haircuts, and repo rates by type of underlying collateral. Repo played only a small role in funding private sector assets prior to the crisis. The subsequent contraction in repo is relatively insignificant compared with the contraction in asset-backed commercial paper. Haircuts in our data rise less than in the interdealer repo market. While relatively small in aggregate, the contraction in repo with private-sector collateral particularly affected key dealer banks and led them to resort to the Fed's emergency lending programs.

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Most analyses of the financial crisis of 2007-09 highlight the rapid expansion of the shadow banking sector in the period from 2000 to 2007 and the subsequent collapse of the sector during the crisis (see Adrian and Shin (2010), Brunnermeier (2009), Gorton and Metrick (2011)). A wide variety of loans, including residential mortgages, auto loans, and credit card loans, which a decade ago were held by the commercial banking sector and financed by bank deposits were instead held by shadow banks and financed by repurchase agreements (repo) and asset-backed commercial paper (ABCP) (see Figure 1). Like deposits of traditional banks, the repo and ABCP liabilities created by shadow banks were of short maturity. However, unlike for traditional bank deposits, there was no regulatory structure that offered safety to the shadow-bank "depositors". In a series of papers, Gorton and Metrick (2010a, 2010b, 2011) have argued that the repo market played a key role in the collapse of the shadow banking system through a "run on repo" very much akin to the runs on commercial banks that plagued the U.S. prior to the establishment of the Federal Reserve System.

Much of the discussion of the repo market has run ahead of our measurement of the repo market (see Geanakoplos (2009); Gorton and Metrick (2010b); Shleifer (2010)). Because of a lack of data, we know little about basic questions: How much did the shadow banking system rely on repo for its short-term funding? How much did it contract during the crisis? How much of repo funding provided by non-banks was collateralized by (securitized) private-sector assets? Did this change during the crisis? As a consequence, it is difficult to evaluate the role played by the repo market in propagating shocks during the financial crisis.

Our objective is to fill this gap with a new data set on the repo agreements between non-bank lenders and dealer banks. To assess the funding conditions for the shadow banking system as a whole, we focus on the repo funding flows that enter the shadow

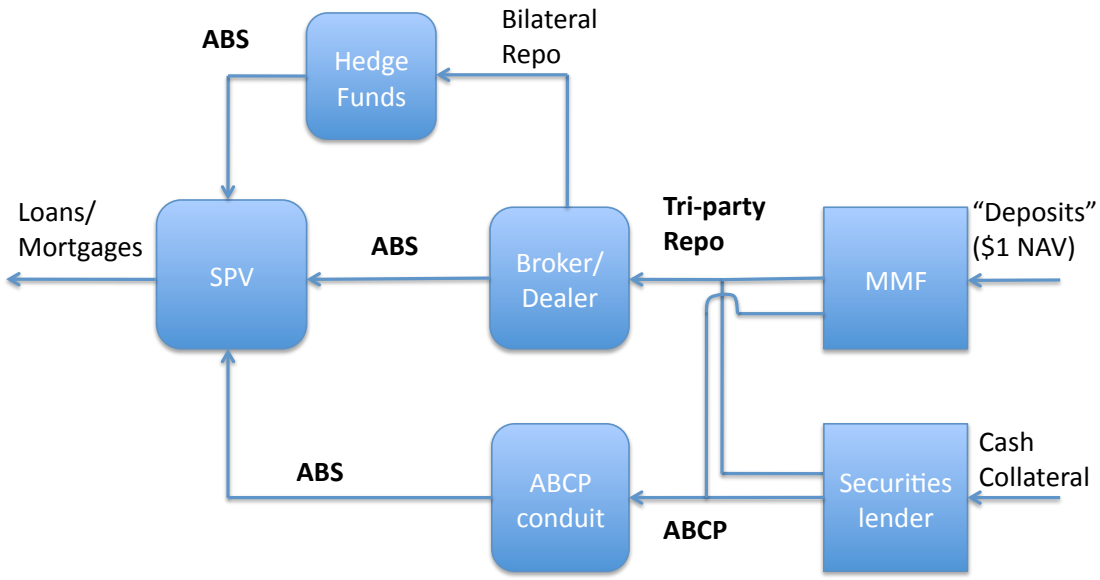


Figure 1: Short-term Funding Flows in the Shadow Banking System. The biggest cash lenders to the shadow banking system are money market funds (MMF) and securities lenders (SL). MMF take short-term funds from retail investors, institutions and corporations, and promise to preserve a fixed $1 net asset value. SL are large institutional investors or custodians for institutional portfolios who lend securities to short-sellers and in return receive cash, as collateral, that they seek to reinvest. A substantial portion of funding provided by MMF and SL to the shadow banking system is provided in collateralized form with repurchase agreements (repo) or asset-backed commercial paper (ABCP). Repo is used by broker/dealers to fund their securities inventory, e.g. of asset-backed securities (ABS) and to fund repo loans that they provide to clients, e.g. hedge funds. ABCP is issued by special purpose vehicles (SPV) set up (usually by commercial banks) for the purpose of purchasing long-term ABS. The repos between MMF/SL and broker/dealers are typically tri-party repos, in which a custodian bank safeguards the collateral on behalf of the cash lender. Repos between broker/dealers and hedge funds are typically bilateral repos without a third party custodian to stand between.

banking system (through the tri-party repo market on the right-hand side of Figure 1) rather than the inter(shadow)bank repo lending between dealers, and between dealers and hedge funds. Statistics on aggregate repo volume in the U.S. such as the commonly cited Primary Dealer repo survey of the Federal Reserve do not distinguish between the flows into the shadow banking system and the flows within the system. Volume statistics are computed by adding up all repos along the intermediation chain from non-banks to dealers and between dealers. The quantity of interdealer repo is informative about the length of intermediation chains within the shadow banking system, but not about how the shadow banking system funds itself in aggregate vis-a-vis non-banks.[1]

To isolate the repo funding flows provided by non-banks, we use data on the repo market activities of money market funds (MMF) complemented with data on repos of security lenders (SL). These sectors are significant lenders of cash in the repo market. For example, in 2007Q2, they lent a total of $930bn of cash in the repo market, which accounts for about two thirds of the total repo funding flows from non-bank lenders to shadow banks. The MMF data is extracted from quarterly SEC filings of MMF. The SL data is from the Risk Management Association (RMA). We also analyze data from the Federal Reserve's emergency lending programs in 2008 and 2009 to understand how much these actions counteracted a contraction in the repo market.

We start by examining the question of how significant was repo in funding private sector assets prior to the crisis. That is, a key channel suggested by the "run on repo" theory is that repo drove the growth of the shadow banking sector and the expansion of privately securitized assets prior to the crisis. We do not find support for this

[1]For the very same reason, interbank deposits are not counted in the calculation of money stock measures like M2. However, the quantity of interbank repo may be relevant for other questions that are not our focus here. For example, a high level of interdealer repo could affect the probability that defaults propagate from dealer to dealer in the same way as a high level of interdealer over-the-counter derivatives exposures could (Duffie and Zhu (2011)). Our focus, however, is not on the systemic risk contribution of interdealer repos but on the role of repo for shadow bank funding in aggregate.

channel. Only a small portion of the outstanding amount of mortgage- and asset-backed securities created in the private sector (private-label ABS) is used as collateral in repo funding. In the period before the crisis, repo from MMF and SL collateralized with private-label ABS total $151bn, which implies that only 3% of outstanding private-label ABS is financed by repo from MMF or SL. Most of the repo funding extended by MMF and SL is collateralized with Treasury or Agency-backed securities.

ABCP and direct holdings of privately securitized assets by MMF and SL play a more significant role than repo as short-term funding sources for the shadow banking system. In the period before the crisis, ABCP finances 23% of the outstanding private-label ABS, which is an order of magnitude larger than repo.

As the crisis unfolds from 2007Q2 to 2009Q2, the short-term funding of private-label ABS contracts by $1.4 trillion. Of this, $662bn comes from the reduction in outstanding ABCP while only $151bn of the contraction comes from the reduction of repo with private-label ABS collateral. The remainder comes from a contraction of direct holdings of private-label ABS by MMF and SL. Moreover, the contraction in short-term funding appears first in the ABCP market during the summer of 2007 (Covitz, Liang, and Suarez (2012)). In contrast, private-label ABS repo keeps growing until the collapse of Bear Stearns in 2008Q1.

These findings are consistent with the views of many commentators that a contraction in the short-term debt of shadow banks played an important role in the collapse of the shadow banking sector, but they are inconsistent with the view that a run on repo played the central role. The more significant short-term debt contraction occurs in ABCP. The latter observation is important for understanding the mechanism through which the short-term debt contraction affected the financial system. While both ABCP and repo are collateralized forms of short-term debt, ABCP typically receives liquidity

support guarantees from a commercial bank rather than a broker/dealer. Commercial banks were affected early in the crisis in the fall of 2007, but shocks to their financing were relatively well contained because of their access to Federal Reserve lending facilities. The key role played by ABCP and the regulated sector also gives greater weight to the regulatory arbitrage arguments of Acharya, Schnabl, and Suarez (2012) as being an important factor in driving the growth of the shadow banking system.

A second key channel through which the "run on repo" may have contributed to the crisis is through the effects of repo contraction on systemically important institutions. That is, while the contraction in repo was relatively insignificant for shadow bank funding in aggregate, its effects may have been amplified if the contraction disproportionately affected key institutions. We find evidence that is supportive of this channel. The contraction is concentrated among dealer banks that are most reliant on the repo market to fund private collateral at the outbreak of the crisis. These banks include Goldman Sachs, Morgan Stanley, Merrill Lynch, and Citigroup; in short, four of the key players in the financial sector. These dealer banks also have the highest perceived credit risk in September 2008, and they borrow most heavily from the TSLF and PDCF emergency lending programs of the Federal Reserve. It is difficult to pin down, however, how much of this was a causal effect of a refusal of repo lenders to extend funding against risky/illiquid collateral, and to what extent dependence on private collateral is just a symptom of weak capital positions, difficulty in obtaining unsecured funding, loss of brokerage business, and collateral calls by derivatives counterparties, as discussed in Duffie (2010).

Our results also highlight that to understand the role of repo during the crisis, it is important to distinguish between funding conditions that dealer banks face when they borrow cash from MMF and SL via (largely tri-party) repo from the funding terms

that dealer banks offer when they lend via (largely bilateral) repo to other dealers or hedge funds. Gorton and Metrick (2010a, 2011) document that haircuts in the interdealer market rose dramatically in the crisis, while we find much smaller increases in the MMF-to-dealer bank haircuts (see also Copeland, Martin, and Walker (2010)). For private-label ABS, for which Gorton and Metrick report the highest haircuts, we observe instead that quantities go to zero.

We argue that dealer balance sheet constraints provide a natural explanation of this divergence between the tri-party and bilateral repo markets. Our data suggest that MMF and SL stop lending when collateral becomes too illiquid or risky, and so we see quantities for these types of collateral going to zero. Compared with MMF, dealer banks are more capable of assessing counterparty and collateral risk, and are in a better position to deal with illiquid collateral in the event of a default. As a result, they are still willing to extent credit to other dealers and to hedge funds against riskier and illiquid collateral. But their shrinking capital during the crisis led dealers to demand higher haircuts to lessen the demands on their own balance sheets. Therefore, high bilateral repo haircuts are not necessarily an indication that a "run on repo" is taking place.

Overall, the picture therefore looks less like the analogue of a traditional bank run by depositors and more like a credit-crunch in which dealers acted defensively given their own capital and liquidity problems, raising credit terms to their borrowers. These higher credit terms are manifest in the higher haircuts observed by Gorton and Metrick. To fully understand the differential behavior of the bilateral and tri-party repo markets, one needs quantity data on the bilateral market. To our knowledge, no such data exists either publicly or with regulators.

The paper most related to ours is Copeland, Martin, and Walker (2010) who ex-

amine data on tri-party repo provided by the two tri-party agents, Bank of New York Mellon and JPMorgan Chase, from July 2008 onwards. Their data has the advantage that it is high frequency, and, for example, sheds light on the Lehman Brothers failure. However, their sample is shorter and does not start until the middle of the financial crisis. We are particularly interested in understanding how the private-label ABS stock was financed pre-crisis, how this financing changed through the crisis, and how it compares with alternative funding sources such as ABCP. Their data is less suited to answering this question. Their data also includes GCF repo which is a type of interdealer repo, and thus creates the double counting problem we have discussed earlier. Nevertheless, their findings are similar to ours. Repo with private-label ABS collateral is a small fraction of total repo. They document a rise in haircuts on repo against private-label ABS which is similar in magnitude to our own findings. They also find that haircuts on Treasuries and Agency securities remain relatively constant during the crisis. The most significant difference in our respective findings is we find little variation in haircuts across counterparties, while they find substantial variation. At least part of the difference in these findings is due to the fact that their sample has a more significant representation of smaller dealer banks, and it appears that these banks drive the counterparty-specific haircut variation.

I. Funding Through Repurchase Agreements

We start by describing the main features of repurchase agreements that are important for understanding our results. A more in-depth treatment of the institutional features of the repo market can be found, e.g., in Duffie (1996), Garbade (2006), and Federal Reserve Bank of New York (2010). To provide perspective on the empirical analysis

that follows, we then outline a simple model of repo markets.

A. Background on Repurchase Agreements

A repo involves the simultaneous sale and forward agreement to repurchase the same, or a similar, security at some point in the future. Effectively, a repo constitutes a collateralized loan in which a cash-rich party lends to a borrower and receives securities as collateral until the loan is repaid. The borrower pays the cash lender interest in the form of the *repo rate*. The borrower typically also has to post collateral in excess of the notional amount of the loan (the *haircut*). The haircut is defined as $h = 1 - F/C$ with collateral value C and notional amount F. For example, a repo in which the borrower receives a loan of \$95m might require collateral worth \$100m, implying that a haircut of 5% is applied to the market value of the collateral.[2]

Repos constitute an important funding source for dealer banks. They use repos to finance securities held on their balance sheets (as market-making inventory, warehousing during the intermediate stages of securitization, or for trading purposes), or to finance repo loans they provided to clients such as hedge funds. In the latter case, dealer banks re-hypothecate the collateral they receive from hedge funds to use as collateral in their repos with cash lenders. King (2008) estimates that about half of the financial instruments held by dealer banks were financed through repos.

In the years before the financial crisis, repos became an important funding source for the shadow banking system. Just like the traditional banking system, the shadow banking system raised short-term funding and directed these short-term funds into

[2]An central development in the 1980s that spurred the growth of repo was that repos received an exemption from automatic stay in bankruptcy (Garbade (2006)). This exemption allows the cash lender in a repo to sell the collateral immediately in the event of default by the borrower without having to await the outcome of lengthy bankruptcy proceedings, thereby reducing the counterparty risk exposure of the cash lender.

relatively illiquid long-term investments, such as corporate securities and loans, as well residential and commercial mortgages, as illustrated in Figure 1. MMF and SL provided a large part of this short-term funding (Pozsar, Adrian, Ashcraft, and Boesky (2010)).

MMF promise their investors a constant net-asset value ("$1 NAV"), which effectively makes their investors' claims similar to the demand deposits of the traditional banking system (but without deposit insurance). Some of the funding provided by MMF went into securitized products through vehicles that issued asset-backed commercial paper (ABCP), while some went via repo to financial institutions that held securitized products and other securities on their balance sheets (see in Figure 1).

SL are another cash-rich party that directed funds to the shadow banking system. As part of their business as custodians for large portfolios of bonds and equity, these institutions lend securities to investors who wish to establish short positions in bond or stock markets. The shorting investor will typically leave cash with the securities lender in an amount at least as high as the value of the borrowed securities. As a result, securities lenders come into possession of a large amount of cash that they seek to reinvest in the money markets. A significant share of this cash went into repos and ABCP.

The repo that we examine in this paper are known as tri-party repos. The other type of repo is known as a bilateral repo. Repo between dealer banks, or between a dealer bank and a hedge fund are typically bilateral, while repo between dealer banks and MMF/SL are typically tri-party. These two contracts may have different terms in practice (repo rates and haircuts). In a tri-party repo, a clearing bank stands as an agent between the borrower and the cash lender, as illustrated in Figure 2. In the U.S., this role is performed either by JPMorgan Chase or Bank of New York Mellon. The

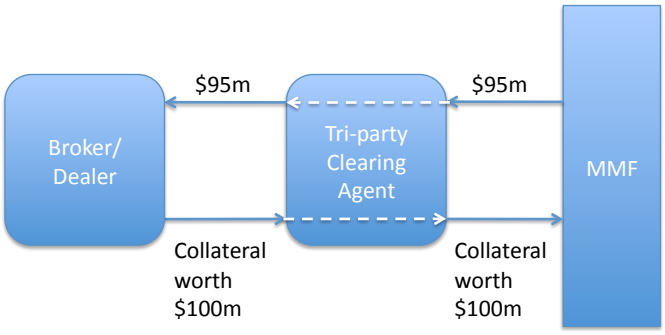


Figure 2: Tri-Party Repurchase Agreements

clearing bank ensures that the repo is properly collateralized within the terms that cash lender and borrower agreed to in the repo (haircut, marking-to-market, and type of securities). The motivation for this tri-party arrangement is to enable cash lenders like MMF that may not have the capability of handling collateral flows and assessing collateral valuations to participate in this market without running the risk that the counterparty might not adequately collateralize the repo.[3]

The risks for a cash lender in a repo are principally that the borrower defaults and the lender does not have sufficient collateral to recover the lent amount. For MMF, there is an additional concern that if the borrower defaults and the collateral is illiquid, the MMF will be stuck with the collateral for an extended period. SEC rules place limits on the amount of illiquid/long-term securities that that an MMF can hold. Finally, there is repo risk unique to the tri-party market that stems from the so-called daily "unwind." Irrespective of the term of the repo, the clearing bank unwinds the repo every morning by depositing cash in the cash-lenders' deposit account with the custodian and by extending an intraday overdraft and returning the collateral to the borrower for use in deliveries during the day. If the term of the repo has not

[3]Garbade (2006) discusses incidents prior to the development of the tri-party repo market in which borrowers had failed to properly collateralize loans.

expired, or if the lender and borrower agree, bilaterally, to renew the repo, a "rewind" takes place at the end of the business day, whereby securities are transferred from the borrower's to the lender's security accounts with the clearing bank, and cash is transferred from the cash lender's to the borrower's deposit accounts. Thus, the cash lender is a secured lender overnight, with the securities underlying the repo serving as collateral, but during the day the cash lender becomes an unsecured depositor in the tri-party custodian.[4] Thus, the risks to a cash lender overnight stem from the interaction of counterparty risk of the borrower with risk of collateral value changes and illiquidity of underlying collateral. Intraday, the risks to a cash lender stem from the counterparty risk of the clearing bank.

The lender can protect against collateral risk by raising the haircut on the repo contract. Reducing the amount of repo lending can be a response to all three risks. The lender can also raise the repo rate to compensate for all three risks, although in practice this appears to be a less significant margin.

Finally, during the sample period we study, there was considerable uncertainty about how a default of a repo borrower would play out in the tri-party repo market. According to the Tri-Party Repo Infrastructure Reform Task Force (see Federal Reserve Bank of New York (2010)), it was not clear for the cash investor if, when, and how a repo trade would be unwound and how the collateral liquidation process would be carried out. The ambiguity over these matters may also affect participation in the repo market.

[4]The potential systemic risk created by the huge intraday overdrafts extended by the two tri-party custodian banks to broker/dealers have also lead to efforts to change the practices in the tri-party repo market (see Federal Reserve Bank of New York (2010)), but for the sample period we study in this paper, the market functioned in the way we described.

B. A Model of Funding and Intermediation Through Repurchase Agreements

To set the stage for our empirical analysis, we sketch a model of repo markets. The model highlights several points that are central to our analysis. First, it clarifies the distinct economic roles of the tri-party repo market (which largely involves lending from non-banks to dealer banks) and the bilateral repo market (which is largely an inter-dealer and dealer-to-hedge fund market). Funding conditions for the shadow banking system in aggregate are set in the tri-party market, while the bilateral market allocates funding within the shadow banking system. The focus of our empirical analysis is on the tri-party market, but the model illustrates potentially important links between tri-party funding and conditions in the biliateral repo market. Collateral illiquidity may trigger reduction in lending quantities in the tri-party repo market. If dealer bank capital is limited, this can lead to a "credit crunch" in the bilateral market in the form of higher haircuts.[5]

Consider an asset that has price today of one. Its value tomorrow and thereafter is either $P = 1 + \sigma$ or $P = 1 - \sigma$. However, the asset may turn illiquid tomorrow. We model this as follows: If a seller wishes to liquidate q assets, then buyers can only be found for a fraction $(1 - \lambda)q$ of the asset and λq of the asset cannot be sold. Here, λ measures the degree of illiquidity and can be thought of as the probability of finding buyers, for example, in a search-theoretic model. A long-horizon investor who is able to hold the asset through the illiquidity period can realize the eventual value of P.

[5]Martin, Skeie, and von Thadden (2012) provide an alternative and complementary theoretical perspective on the differences between tri-party and bilateral repo markets. They focus on the fact that tri-party repo haircuts are not negotiated trade by trade, but are fixed in custodial agreements that are revised only infrequently. As a consequence, lenders in the tri-party repo market are more likely to stop lending altogether, while in bilateral repo lenders may keep lending, albeit at higher haircuts, if collateral risk increases.

There is a unit measure of cash lenders ("MMF") indexed by $i \in [0, 1]$, where lender i has cash a_i to invest. MMF lend via a repo collateralized by the asset. We fix the interest rate on this loan to be $r = 0$ and focus on the determination of the quantity of lending and the haircut on lending. MMF face two constraints. First, they are unwilling to accept default risk. This implies that the haircut is set sufficiently high to ensure that lending is default free,

$$h^m \geq \sigma. \tag{1}$$

Second, they are sensitive to the potential illiquidity of the asset. All MMF face the restriction that they can allocate only a fraction α of their portfolio to (potentially) illiquid investments. This restriction captures the SEC regulations on liquidity in MMF portfolios as well as endogenous restrictions that the funds place on themselves given that their liabilities are demandable. This assumption implies that MMF i chooses quantity of lending of q_i such that,

$$q_i \lambda \leq a_i \alpha \qquad \Rightarrow \qquad q_i \leq \frac{\alpha}{\lambda} a_i. \tag{2}$$

Higher haircuts do not help to relax this constraint. For example, suppose $\lambda = 0.5$, $\sigma = 0.2$, and the MMF lends \$100 against \$200 worth of the asset (200 units), as collateral, i.e., with collateral far in excess of what is required to keep the loan default-free. Now suppose that the asset value falls to $1 - \sigma = 0.8$ and the borrower defaults. The MMF can only realize \$80 by selling the portion $(1 - \lambda)$ of the collateral immediately, because the rest is temporarily illiquid. Nevertheless, one unit of the asset would be judged to have a fair value of \$0.80, and so the MMF can only keep (and liquidate) $(1/0.8) \times 100 = 125$ units of the collateral, while the rest would go back to the borrower. The 125 units would fully cover the borrowers liability of \$100 at fair value of the asset,

but this leaves the MMF with an illiquid portion of $\lambda \times \$100$. In aggregate, (2) implies

$$Q^m \leq \frac{\alpha}{\lambda} A, \tag{3}$$

where $A = \int_{i\in[0,1]} a_i di$ is the aggregate cash available to the MMF sector and $Q^m = \int_{i\in[0,1]} q_i di$. Thus, as the asset becomes more illiquid and λ rises, it is possible that the liquidity constraint binds and the quantity of lending falls.

MMF lend via the tri-party repo market to dealer banks who in turn lend via the bilateral repo market to other dealers as well as hedge funds. Denote the haircut that dealer banks charge on their lending as h^b. We assume that dealers also require that repo lending be default free so that $h^b \geq \sigma$ and that the interest rate on lending is fixed at r. We aim to show that h^b may exceed σ (and thus h^m). We assume that, unlike MMF, dealers are not directly concerned about the liquidity of the underlying collateral. Let us index the dealer banks by $j \in [0, 1]$ where dealer j has equity capital of e_j, which we assume to be fixed in the short-run. In aggregate, their lending

$$Q^b \leq E^b + Q^m \tag{4}$$

is constrained by their aggregate equity capital, $E^b = \int_{j\in[0,1]} e_j dj$, and the lending offered by MMF.

Last consider the hedge fund sector (and other leveraged sectors) who are the ultimate borrowers in the bilateral repo market. We assume that the sector has aggregate equity E^h and borrows the maximum possible amount from dealers. Given the haircut h^b set by dealers, hedge funds need to finance a portion h^b of any collateral holdings C^h with their own equity, i.e, $E^h = h^b C^h$, and hence their demand for repo borrowing

from dealers is $D^h = (1 - h^b)C^h$, or

$$D^h = (1 - h^b)\frac{E^h}{h^b}, \tag{5}$$

posting C^h worth of collateral. The dealer in turn rehypothecates this collateral to the MMF that lends to the dealer.

There are two regimes. In the unconstrained regime, dealers' constraint (4) does not bind because λ is sufficiently low relative to α so that the liquidity constraint of MMF is slack, E^b is sufficiently high, or E^h is low so that hedge funds' demand for borrowing in the repo market is low. If MMF and dealers maximize the amount of lending subject to the no-default-risk constraint, dealers and MMF will set

$$h^b = \sigma, \quad h^m = \sigma, \tag{6}$$

and the bilateral repo haircut is equal to the haircut in the tri-party repo market. We refer to this as the "no credit crunch" regime. An interesting case is that of a liquid security such as Treasuries where λ is equal to zero. In this case, there is no liquidity constraint on MMF lending and MMF are willing to lend up to A. Typical haircuts on Treasuries (i.e. σ) are 2%. Assuming that $D^h < A$ for $h^b = 0.02$, then the haircut on Treasuries in both bilateral and tri-party repo is equal to 2% regardless of the conditions of broker/dealer balance sheets. Even with zero equity, dealers could just take the excess collateral of $0.02 \times D^h$ posted with them to obtain a loan $Q^m = D^h$ from MMF, posting $0.02 \times Q^m = 0.02 \times D^h$ excess collateral. That is, dealer banks in this case are simply a pass through that lends to hedge funds and rehypothecates the collateral to MMF to rase the cash for the hedge fund loan.

In the "credit crunch" regime, E^h is sufficiently high, E^b is sufficiently low, or λ

sufficiently high relative to α, so that the constraint (4) binds. With the amount of lending constrained, h^b adjusts to clear the market $Q^b = D^h$. Substituting (5) into (4) with equality, and we obtain

$$h^b = \frac{E^h}{E^b + Q^m + E^h} > \sigma. \tag{7}$$

We then have three comparative statics: A fall in E^b is a left-shift in the repo supply function and hence h^b rises; a fall in Q^m is a left-shift in the repo supply function and hence h^b rises; and a rise in E^h is a right shift in the repo demand function and hence h^b rises.

The model foreshadows our basic finding Sections in III to V that when private collateral turns illiquid, the quantity of lending from MMF falls, but with little change in tri-party repo haircuts. In contrast, bilateral haircuts rise as dealer banks' balance sheet capacity is limited. This provides a credit crunch explanation for the high bilateral haircuts reported in Gorton and Metrick (2010a, 2011). High bilateral repo haircuts are therefore not necessarily an indication that a "run on repo" is taking place. Shrinking equity capital can also lead dealers to raise haircuts to their borrowers. At the same time, a reduction in lending from MMF that is relatively small in aggregate could potentially have large effects on dealers with a fragile capital structure. We look into this issue in our analysis of individual dealer banks in Section VI.

II. Repo Data

To examine the "run on repo" hypothesis, we now turn to data on the terms and quantities of repo lending by the ultimate cash lenders, MMF and SL, in the tri-party repo market. We first outline the data sources, and then we discuss the extent to which

these data sources cover the universe of repo funding flows into the shadow banking system.

A. Data Sources

Mutual funds file a portfolio holdings report every quarter on forms N-CSR, N-CSRS, and N-Q with the Securities and Exchange Commission (SEC). This filing requirements also extends to MMF. The typical report of an MMF lists their holdings of certificates of deposits, commercial paper, and repurchase agreements. For repos, the reports list each repurchase agreement with the notional amount, repo rate, initiation date, repurchase date, counterparty, the type of collateral, and, in most cases, the value of the collateral at the report date. The level of detail about the underlying collateral varies between funds. Some report fairly detailed categories, while others only report broad classes, such as "U.S. Treasury Bonds", "Government Agency Obligations", or "Corporate Bonds", often with a maturity range. Typically a portfolio of securities serves as collateral, but only rarely are the value-weights of different classes of securities in the portfolio reported. In most cases, though, the collateral portfolio consists of securities of the same type (e.g., U.S. Treasury bonds of different maturities and vintages, rather than Treasury bonds mixed with corporate bonds or asset-backed securities).

We collect the quarterly filings from the SEC website with filing dates between January 2007 and June 2010. We parse the filings electronically and extract the repurchase agreement information. We collect the data for the 20 biggest fund money market fund families at the end of 2006, identified from a ranking of money market fund families obtained from Cranedata (see Appendix A for a list of the families in the sample). This yields a data set of approximately 16,000 repos. As the market for money market funds is fairly concentrated, with the biggest 20 fund families accounting for more than 80%

of total net assets, our data should give us a fairly complete picture of the repo market between MMF and dealer banks. In all of the computations below, we extrapolate the MMF data we have collected to the entire MMF sector by scaling it up to match the total repo from the Flow of Funds accounts (FoF) each quarter. While we refer to the funds in our sample in general as MMF, some funds in the sample are enhanced cash funds that are, strictly speaking, not money market funds, as they do not adhere to the investment restrictions for money market funds in SEC rule 2a-7 and particularly do not aim for $1 NAV. Also, not necessarily all of the repos in our data are tri-party, but conversations with market participants confirmed that the vast majority of MMF repo are tri-party.

To analyze securities lenders, the second main class of providers of short-term funding to shadow banks, we obtain data from the Risk Management Association (RMA). The RMA conducts a quarterly survey of major securities lenders and reports statistics on their aggregate portfolio of cash collateral reinvestments, including direct investments as well as repo agreements. Appendix B provides more detail on the data, including a list of survey participants quarter-by-quarter. The RMA data combine repo with private-label ABS and corporate debt into one category. We impute the split between private-label ABS and corporate debt based on the assumption that their relative proportion is the same as the corresponding proportion in MMF repos.

B. Coverage of Repo Funding Flows

The main objective of our data collection is to capture the repo funding flows that enter the shadow banking system. One concern that may arise is that our data on MMF and SL might miss important repo lenders. If so, we would not have a full picture of the repo funding extended to shadow banks.

In 2007Q4, our total coverage of repo from MMF and SL is $1.1tn. The Flow of Funds (FoF) accounts for 2007Q4 (December 2010 release) report that the other large repo lenders were State and Local Governments ($163bn),[6] Government Sponsored Enterprises ($143bn), and Rest of the World ($338bn). The Treasury's TIC data puts the repo lending of foreign central banks at between $100 and $200bn (these numbers are likely incorporated in the Flow of Funds' Rest of the World entry). If these FoF estimates are correct, then our data covers about two-thirds of repo lenders. However, because data on the repo market is scant, there is uncertainty in these FoF estimates. For this reason, why did some further analysis of commercial banks and non-financial corporations as potential repo lenders.

Commercial banks are not on our list of repo lenders above, because they are net repo *borrowers* according to the FoF. However, there could be important heterogeneity within the commercial bank universe. For example, it is possible that deposit-rich local banks are net repo lenders while big money center banks are net borrowers. To check this, we turned to the FDIC's Call Reports for 2007Q4. Aggregating the net repo positions of all banks that are net lenders yields total net repo lending of $112bn (gross lending of $177bn). Thus, bank deposits appear to fund some repo lending to the shadow banking system. But the numbers are nevertheless relatively small compared with the repo lending of MMF and SL.

Looking at some of the most cash-rich non-financial corporations, we did not find other significant sources of repo funding. According to its 2007 Annual report, Microsoft held $23.4bn cash and short-term investments. Of this amount, $3.0bn is in

[6]Repos by state and local governments are typically backed by Treasury and Agency collateral, and are therefore not a likely funding source for private-label ABS. For example, California Government Code Section 53601 restricts repo collateral to government, agency, and municipal securities and prime commercial paper. In Illinois, the Deposit of State Moneys Act (15 ILCS 520/22.5) allows only repo collateralized by government securities.

cash, and the remainder is in government, agency, and corporate bonds, MBS, municipal securities, mutual funds, commercial paper, and certificates of deposit. While some of Microsoft's mutual fund investments might flow into repo markets through MMF, these institutional MMF are already covered in our MMF sample. Similarly, Apple reports $15.4bn cash and short-term investments in its 2007 annual report, of which $256m is held as cash and the rest is wholly invested in government, agency, and corporate securities, where corporate securities include commercial paper, certificates of deposit, and time deposits. The numbers in the FoF are consistent with these two examples: Non-financial businesses have a small net repo lending position of $8bn (compared with holdings of MMF shares of $619bn and domestic deposits of $1.4tn).

Overall, our analysis has not turned up other major sources of repo funding. Our MMF and SL data appears to cover close to two thirds of the repo funding flows into the shadow banking system. Moreover, some of the repo lenders not covered by our MMF/SL data (such as state and local governments and central banks) are unlikely sources of funding for private-label ABS collateral.

III. Quantity and Composition of Repo Funding

We use the repo data to tackle the first and most basic question: What is the total amount of repo funding that MMF and SL extend to the shadow banking system? We then look at the composition of repo funding by type of collateral.

A. Quantity of Repo Funding

The first column in Table I reports the aggregate amount of repos undertaken by MMF in our SEC filings data set. In 2006Q4 we have only partial coverage because we miss

2006Q4 reports filed before January 2007. For comparison, the second column shows the aggregate amount of MMF repo outstanding according to the FoF, and the third column shows the total amount of MMF assets, also from the FoF. Our data set covers roughly 80-90% of oustanding MMF repo. Repos account for about 15-20% of total MMF assets.

Column four reports the total amount of repo oustanding in securities lenders' cash collateral reinvestment portfolios. Until 2008Q2, this number is of comparable magnitude as the total amount of MMF repo, but it contracts more strongly in subsequent quarters. This is likely driven by the fact that the total amount of cash collateral available to SL for reinvestment contracted sharply around the peak of the crisis. The amount of MMF repo did not shrink appreciably until 2009Q2. One factor driving the total size of MMF repo seems to be the flows in and out of MMF. MMF assets increased by about 50% from 2007Q1 to 2009Q2.

The final column shows the end-of-quarter amount of total Primary Dealer repos outstanding, as reported by the Federal Reserve Bank of New York. A comparison of these numbers with the total amount of MMF and SL repo shows an interesting and stark contrast: The Fed's Primary Dealer repo numbers are about four times as high as the MMF and SL repos combined. This difference arises because the Primary Dealer statistics aggregate all repo transactions of Primary Dealers, including repos done between dealers and with hedge funds, while the MMF and SL repo covers only the funding raised from non-banks to shadow banks.

Repos between shadow bank intermediaries are common and involve re-hypothecation of collateral along the intermediation chain. As an example, suppose dealer bank A lends \$1 to a hedge fund via a repo (collateralized by \$1.02 of Treasuries),[7] and then

[7]From the perspective of the hedge fund, this is a repo, from the perspective of dealer bank A it

Table I: Quantity of Repo Funding Provided by Money Market Funds and Securities Lenders

	Money Market Funds			Securities Lenders		Primary
Quarter	Collected Repo	Total Repo[2]	Total Assets[2]	Repo	Cash Collateral	Dealer Repo[3]
2006Q4	243[1]	395	2,312	431	1,594	3,442
2007Q1	324	387	2,372	527	1,834	3,619
2007Q2	331	426	2,466	504	1,902	3,889
2007Q3	412	528	2,780	522	1,754	3,886
2007Q4	483	606	3,033	478	1,712	4,106
2008Q1	501	592	3,383	467	1,537	4,278
2008Q2	466	518	3,318	509	1,790	4,222
2008Q3	433	592	3,355	490	1,519	3,989
2008Q4	479	542	3,757	228	954	3,208
2009Q1	546	562	3,739	212	779	2,743
2009Q2	507	488	3,585	257	882	2,582
2009Q3	495	495	3,363	244	865	2,499
2009Q4	472	480	3,259	229	850	2,469
2010Q1	427	440	2,931	263	837	2,477

[1] Incomplete coverage of funds in MMF sample in 2006Q4.
[2] Source: Flow of Funds Accounts.
[3] Source: Federal Reseve Bank of New York

borrows the $1 from dealer bank B via a repo (collateralized by the same $1.02 of Treasuries), who then borrows $1 from a MMF (collateralized by the same $1.02 of Treasuries). The MMF does not re-hypothecate collateral. This chain is typical in the repo market, as dealer banks both borrow and lend cash and rehypothecate collateral extensively (Singh and Aitken (2010)). Note that sum of repo loans across these four institutions is $3. The Fed's Primary Dealer statistics would report total repos of $2, i.e., the sum of the two repos that involve dealers as the party receiving funds. However, the amount of repo funding extended by non-banks to the shadow banking

is a reverse repo

sector is only the $1 from the MMF to dealer bank B. Interdealer repos do not raise funding for the shadow banking system, but instead reallocate funds within the shadow banking system.

Repos between shadow bank intermediaries and hedge fund also often involve simultaneous repo/reverse-repo trades in which a dealer obtains one security as collateral (say, a Treasury bond) from a hedge fund client in a reverse-repo transaction and at the same time delivers another one (say, a corporate bond) to the same hedge fund in a repo transaction. These transactions are effectively just an exchange of one security against another and hence do not provide net funding to dealer banks. The repo leg of these trades is included in the Fed's Primary Dealer repo statistics.[8]

For these reasons, the amount of repo funding provided by non-banks shadow banks, and the extent of its contraction, cannot be inferred from the Federal Reserve's Primary Dealer repo statistics. Estimates of the total size of the repo market based on the Primary Dealer repo numbers, as in Adrian and Shin (2009) or Gorton and Metrick (2011), are difficult to interpret, because these estimates do not distinguish between length of intermediation chains within the shadow banking system from the repo funding raised from outside the system. The shortening of intermediation chains that is implied by the sharp contraction in Primary Dealer repo may be informative about other problems in the shadow banking system that are not our focus here. For example, dealers may have tried to reduce network exposures to vulnerable dealers, which made them more

[8]The substantial extent of these simultaneous repo/reverse repo transactions can be estimated from dealers' off-balance sheet pledged collateral. FASB interpretation (FIN) 41 allows netting of the repo and reverse repo if they are both with the same counterparty and same maturity. For example, Goldman Sachs' broker/dealer subsidiary reported, in its November 2006 FOCUS report filed with the SEC, a total of $489bn of collateral owned or received that was pledged, while the balance sheet only reports a total of $306bn repos, securities loaned, and financial instruments sold but not yet purchased. The difference of $183bn likely reflects repos netted with reverse repos, or similar transactions, that satisfied the requirements for netting of FIN 41. See King (2008) for similar calculations for several dealer banks in 2008.

reluctant to lend to each other, and which inhibited the efficient allocation of liquidity within the shadow banking system.

A better benchmark against which to compare our data coverage is the size of the tri-party repo market. According to data from Bank of New York Mellon and J.P. Morgan, the total amount of tri-party repo was roughly $2.5 trillion at the end of 2007 (Federal Reserve Bank of New York (2010)), which compares with about $1.1 trillion of MMF and SL repo in our data. However, the Bank of New York Mellon and J.P. Morgan numbers also include GCF repo, which is a form of interdealer repo (see Copeland, Martin, and Walker (2010)). Our earlier analysis of Flow of Funds Accounts data suggest that our MMF and SL data captures about two thirds of the repo funding provided to the shadow banking system.

B. Composition by Type of Collateral

We next turn to evaluating the conjecture by Gorton and Metrick (2010a, 2010b, 2011) that private-label ABS played an important role as the collateral that backed repo "money."

Figure 3 presents the share (by notional value) accounted for by different collateral categories, reported for each quarter. The "Agency" category includes both Agency bonds and Agency-backed MBS (many funds lump these together when reporting collateral, so we cannot distinguish them in most cases). The "Priv. ABS" category includes private-label ABS. The "Corporate" category refers to corporate debt, and the "Other" category is composed mainly of equities, whole loan repos, and some commercial paper, certificates of deposit, and municipal debt.

The most striking fact in this figure is the relatively small role played by private-label ABS collateral. Treasury and Agency securities account for the majority of collat-

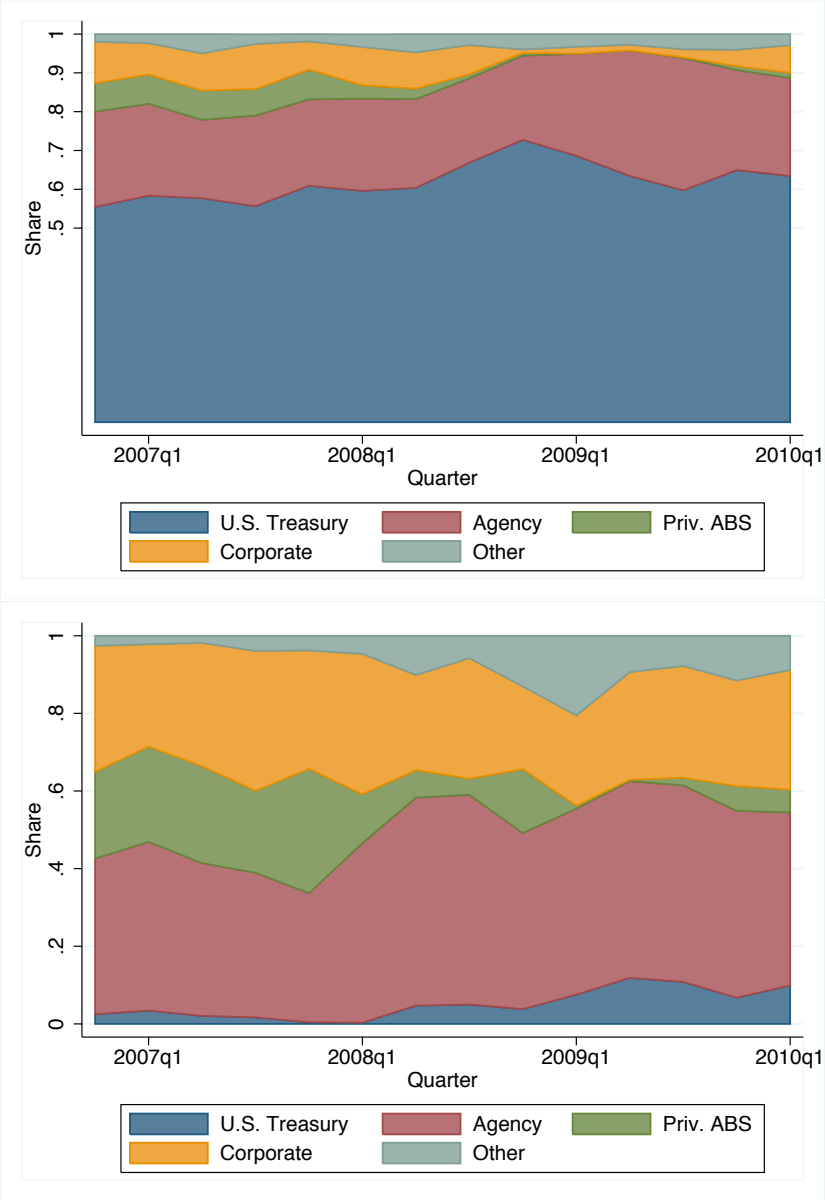


Figure 3: Share of collateral types for money market fund repo (top) and securities lender repo (bottom). The RMA data for securities lenders combines corporate and private-label ABS collateral. The split shown in this figure is imputed based on the assumption that the relative proportion of corporate and private-label ABS collateral is the same as for MMF.

eral in MMF repos. Private-label ABS make up less than 10% of MMF repo collateral prior to the crisis, which corresponds to about $31 billion in terms of value. For SL, Agency and Treasury securities account for roughly 50% of repo, with private label collateral making up a more significant portion of the porfolio.

Private-label ABS disappears as collateral from MMF as the financial crisis reaches its peak in 2008. Corporate debt also disappears almost entirely. Thus, riskier and less liquid collateral were not used for financing in the tri-party repo market at that time. For SL, we observe the same pattern of a reduction in the share of riskier and less liquid collateral during the crisis. The disappearance of private credit instruments as collateral is less extreme, though, than for MMF. The reduction of repo against private-label ABS reflects the "run on repo" that many have commented on and we will delve more into this run in the next sections.

IV. Short-term Funding of Private Credit Instruments

We next ask how repo compares as a funding source for private-sector securitized assets to other forms of short-term funding. We focus particularly on the importance of ABCP vis-a-vis repo because both are proto-typical shadow banking transactions involving relatively safe short-term funding a private sector asset.

A. Short-term Funding at the Onset of the Financial Crisis

The first row of Table II presents data on the total outstanding U.S. private-label ABS in 2007Q2. The $5.213tn outstanding is the heart of what is commonly referred to as

Table II: Funding of Outstanding U.S. Private-Label ABS and Corporate Bonds in 2007Q2 ($bn)

	Private-label ABS		Corporate Bonds	
	Amount	%	Amount	%
Total outstanding[1]	5,213	100%	5,591	100%
Short-term funding				
ABCP[2]	1,173	23%		
Direct holdings[3]				
MMF	243	5%	179	3%
Securities lenders	502	10%	369	7%
Repo[4]				
MMF	31	1%	42	1%
Securities lenders	120	2%	166	3%
Total short-term	2,069	40%	755	14%

[1] Souce: SIFMA for ABS, where ABS is ex CDO of ABS (the latter estimated as in He, Khang, and Krishnamurthy (2010)); Flow of Funds for corporate bonds, ex bonds issued by foreigners and ABS issuers.

[2] Source: Federal Reserve Board.

[3] Source: Risk management Association (RMA) for securities lenders, and Flow of Funds for total direct holdings by MMF of corporate bonds including ABS. The direct holdings estimate for MMF is based on the assumption that the ratio of private-label ABS holdings to corporate bonds is the same for MMF as the observed one for securities lenders.

[4] RMA (securities lenders) and SEC filings (MMF). The MMF repo numbers from our SEC filings data are scaled up to match the total amount of MMF repo according to the Flow of Funds. The RMA data combines repos with corporate and private-label ABS collateral. The repo estimate for securities lenders is based on the assumption that the ratio of repos with private-label ABS to repos with corporate debt securities collateral is the same for securities lenders as the observed one for MMF.

the shadow-banking sector; i.e., residential mortgages and other loans that are held in securitization pools or in SPVs. The main sub-categories in the $5.213tn are roughly $3tn private-label RMBS and CMBS (data from the Securities Industry and Financial Market Association), which include about $1.4tn subprime RMBS outstanding at the onset of the crisis (Greenlaw, Hatzius, Kashyap, and Shin (2008)). We also provide data on the outstanding corporate bonds as some of these securities (e.g., bonds used to finance LBOs, senior bank loans) also comprise the shadow banking sector. The outstanding amount of corporate debt, excluding commercial paper, was $5.591tn in 2007Q2.

The table also details the amount of these securities financed by repo from MMF or SL. Total repo of private-label ABS is $151bn. Even if we include the repo extended against corporate bonds, the repo total is only $359bn. This is a small fraction of the outstanding assets of shadow banks. This observation underscores a principal finding of this study: repo was of far less importance in funding the shadow-banking sector than is commonly assumed.

If repo was not the principal source of short-term funding, what was? The table details the direct holdings of these securities by MMF and SL. The direct holdings are substantial, totaling $745bn. It is likely that such holdings are high grade and short maturity tranches of securitization deals. The largest source of funding is ABCP of $1,173bn.[9] The comparison between ABCP and repo shows that ABCP was probably

[9]Acharya, Schnabl, and Suarez (2012) note that the assets in the SPVs financed by ABCP are a 50-50 mix of ABS and other loans (receivables or whole bank loans). As they point out, when an SPV contains loans rather than already-securitized assets, one can think of ABCP as the first layer of securitization (which may be temporary if loans are "warehoused" in the SPV until they are eventually permanently securitized). In this case, too, the shadow banking system funds long-term assets with short-term debt, and hence it makes sense to include the full amount of ABCP in our comparison here because this is one channel through which the shadow banking system funds long-term assets. One could therefore also add about 50% of ABCP as first-layer securitization to the headline amount of outstanding ABS/MBS, but this would not materially change the message of the table.

more important as a stress-point for the shadow banking system.

B. Contraction in Short-term Funding During the Financial Crisis

Table III documents the contraction in short-term funding of the shadow banking sector between 2007Q2 and 2009Q1. Total repo for private-label ABS goes to almost zero. However, as we have noted, the quantity of contraction is modest since repo was a relatively small source of funding. The contraction in repo funding accounts for only about 10% of the total short-term funding contraction of roughly $1.4 trillion.

A striking fact is that repo with private-label ABS collateral completely disappears. Thus, even though the total contraction is small, it seems possible that institutions that were entirely reliant on repo were particularly affected by the reduction in repo with private collateral. We return to this point later in the paper. For example, this observation may square with accounts of the failures of Bear Stearns and Lehman Brothers (see Duffie (2010)).

For the entire shadow bank sector though, the more important contraction was in ABCP, which falls by $662bn. Direct holdings of ABS by MMF and SL also falls by $568bn. The bottom panel of the table documents the contraction in corporate bonds. The contraction is more modest, and this is likely driven by the fact that corporate bonds did not suffer from the same rise in perceived risk and illiquidity as ABS.

Figure 4 illustrates the contraction in ABCP and repo graphically, quarter-by-quarter. The figure compares the amount of repo with private-label ABS collateral with the amount of ABCP outstanding, net of the amount funded through the Federal Reserve's Commercial Paper Funding Facility (see Adrian, Kimbrough, and Marchoni

Table III: Contraction in Short-term Funding ($bn.)

	2007Q2	2009Q1	Contraction
private-label ABS			
ABCP[1]	1173.2	511.0	-662.2
Direct holdings			
MMF[3]	243.3	59.4	-183.9
Securities lenders[2]	501.6	116.0	-385.6
Repo			
MMF	30.5	0.3	-30.2
Securities lenders[4]	120.1	1.6	-118.5
Total			-1380.4
Corporate bonds			
Direct holdings			
MMF[3]	178.9	158.4	-20.5
Securities lenders	368.7	309.1	-59.6
Repo			
MMF	42.1	9.7	-32.4
Securities lenders[4]	165.6	49.3	-116.3
Total			-228.8

[1] Source: Federal Reserve Board. ABCP outstanding less the amount of ABCP financed through the Commercial Paper Funding Facility ($116.8bn in 2009Q1).
[2] Part of these holdings is in the form of ABCP, part in direct holdings of long-term ABS (i.e., possible double-counting with ABCP)
[3] The direct holdings estimate for MMF is based on the assumption that the ratio of private-label ABS holdings to corporate bonds is the same for MMF as the observed one for securities lenders.
[4] Risk management Association (RMA) and SEC filings (MMF). The RMA data combines repos with corporate and private-label ABS collateral. The repo estimate for securities lenders is based on the assumption that the share of repos with private-label ABS to repos with corporate debt securities collateral is the same for securities lenders as the observed one for MMF.

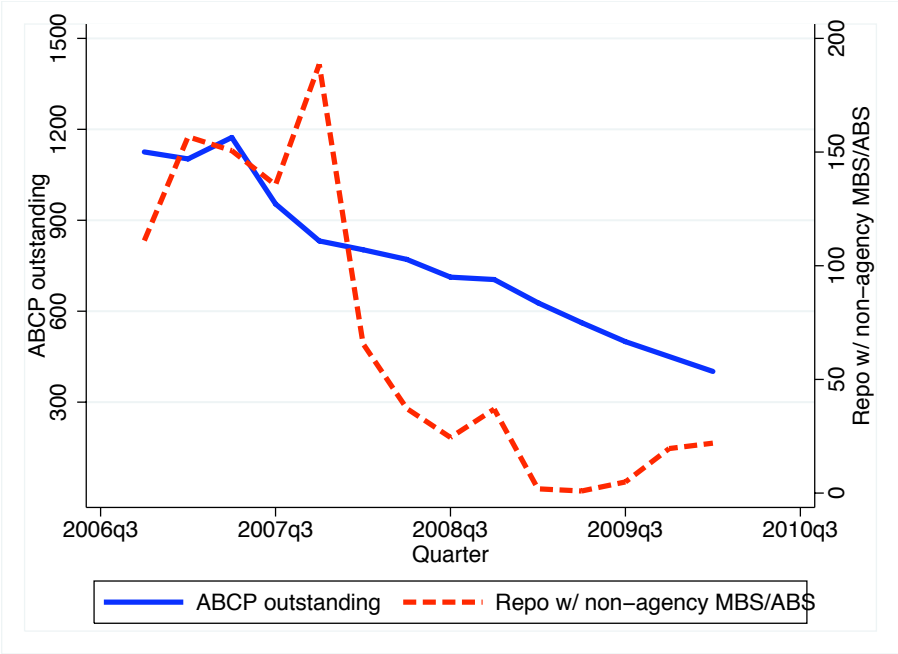


Figure 4: Comparison of private-label ABS repo with ABCP outstanding (ex CPFF)

(2011)). The contraction in ABCP starts earlier than that of repo and continues steadily through the crisis. The repo contraction occurs in a small window around 2008 Q1, roughly corresponding to the failure Bear Stearns. The fact that the contraction in repo with private-label ABS starts later than ABCP indicates that the initial cracks in shadow bank funding appeared in ABCP, not in the repo market.

The contraction in both repo and ABCP are consistent with the views of many commentators that a contraction in the short-term debt of shadow banks played an important role in the collapse of the shadow banking sector. While there are similarities between repo and ABCP, the observation that ABCP plays a more important role than repo in the short-term funding contraction is important for understanding the mechanisms behind the spill-over into the wider financial system. While both ABCP and repo are collateralized forms of short-term debt, ABCP typically receives liquidity support guarantees from a commercial bank rather than a broker/dealer. When the

SPVs backed by ABCP could no longer roll over their short-term debt, their assets came back onto the balance sheets of sponsoring banks (Covitz, Liang, and Suarez (2012), He, Khang, and Krishnamurthy (2010)), spreading the problem to the regulated banking system. The liquidity problems created by this loss of funding was relatively contained because commercial banks had direct access to funding from the Federal Reserve. The problem that commercial banks faced as a consequence was less one of funding liquidity than the problem that supposedly off-balance sheet assets of dubious value migrated back onto their balance sheets depleting their capital.

The relative importance of ABCP in funding private-label ABS also sheds some light on potential drivers of the run-up in short-term debt financing prior to the crisis. The fact that the run-up and crash was concentrated in a part of the shadow banking system that operated with implicit and explicit (but off-balance sheet) support from regulated banks supports the regulatory arbitrage arguments of Acharya, Schnabl, and Suarez (2012). The extensive involvement of European commercial banks in the ABCP business further points towards the global imbalances argument of Caballero and Krishnamurthy (2009) and the global banking glut theory of Shin (2011).

C. Demand or Supply?

One thorny issue to sort out from this data is whether or not the contraction in outstanding volumes was driven by supply forces or demand forces. That is, one interpretation of this data is that cash investors including MMF and SL change their portfolios to avoid ABS repo and ABCP ("repo supply"). A natural explanation for the fall in loan supply is that the underlying collateral became illiquid, and higher haircuts do not offer protection against illiquidity, as in our model in Section I.B, leading cash investors to cut lending altogether. It is also possible, though, that hedge funds and

dealer banks, motivated by the increased risk and uncertainty in asset markets, chose to reduce their holdings of securities and hence no longer needed funding from the repo markets ("repo demand").

The quantity data is suggestive of a supply contraction (we discuss the price data in the next section). First, the outstanding amount of securities in SPVs backing ABCP was essentially fixed over this period. That is, banks sponsored the SPVs, filled them with loans and securities, and issued ABCP and other claims against them, letting them wind down as the loans and securities matured. The banks were not taking an active decision to increase or decrease the loans/securities in the SPV. Thus, at least for ABCP, it is likely that all of the action is driven by loan supply forces. Since ABCP and repo are close substitutes for an MMF or SL, it is likely that the desire to not own ABCP is mirrored in a desire to not own repo. Thus, it is likely that the contraction in repo is also driven by supply forces.

Second, the fact that repo quantity goes to zero also suggests that supply was at work. While dealer banks and hedge funds reduce their holdings of ABS/MBS over this period (see He, Khang, and Krishnamurthy (2010)), they did not reduce their holdings to zero, and so a financing need still existed.

Last, flows into money market funds provide another indication that the contraction was driven by supply-side effects. From September to December 2008, taxable government money market funds received inflows of $489 billion while taxable non-government money market funds experienced outflows of $234 billion (data from the Investment Company Institute). Thus, part of the reduction in repo of non-goverment securities, and the increase in repo with government securities during the later stages of the crisis may have been driven by investors' reallocation between money market funds that invest only in government securities and other money market funds.

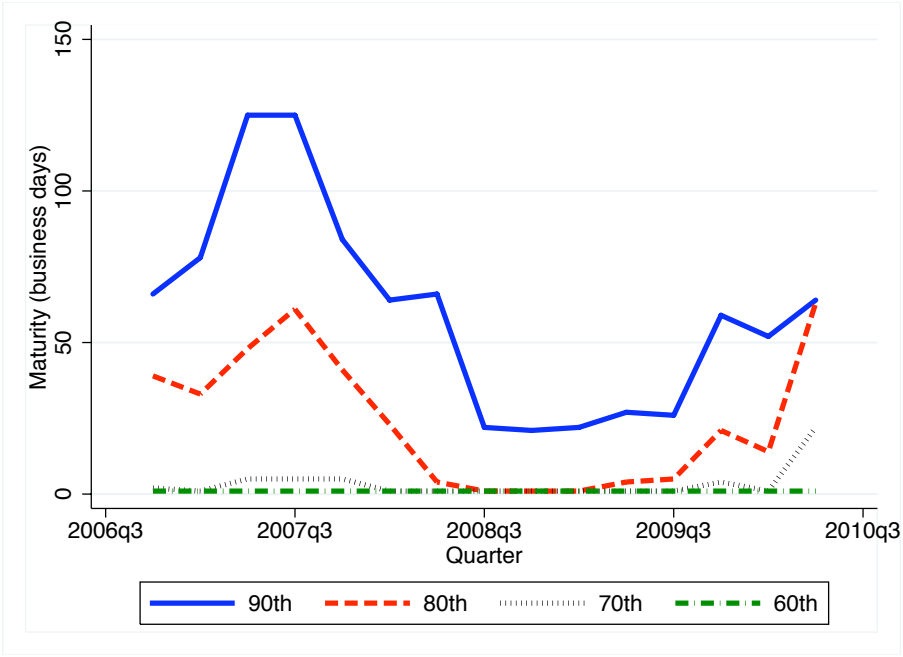
V. Repo Terms During the Financial Crisis

This section presents data on the evolution of the terms of repo contracts, including repo rates, haircuts, and repo maturities. The analysis is based on the MMF repo data. The data we present suggests that the "price" of repo borrowing rose over the crisis. In conjunction with the quantity evidence, the results further suggests that a central factor driving repo market dynamics in the crisis was the desire of cash lenders to avoid lending against ABS collateral. The data on the change of contract terms also suggest that it is a combination of risk-aversion and illiquidity aversion that drives cash lender behavior.

A. Maturity Compression

Figure 5 illustrates the shortening in the maturity structure of repos over the crisis. In general, the majority of repo contracts are overnight. In equal-weighted terms (top panel), the 90th percentile reached 120 business days in 2007, but it subsequently shrank to 20 business days. In value-weighted terms (bottom panel), the figure shows a similar pattern, but the maturity compression is more concentrated in the tail since the overwhelming majority of large repos are overnight. The reduction in maturity is consistent with an increased demand for liquidity from cash-investors, since shorter maturity repo is de-facto more liquid than longer maturity repo. Krishnamurthy (2010) provides evidence of investors' increased desire for liquidity over the crisis, as reflected in a number of different asset markets. That is, the data in Figure 5 is reflective of a more general phenomenon that played out over the crisis.

(a) Equally weighted



(b) Weighted by notional value

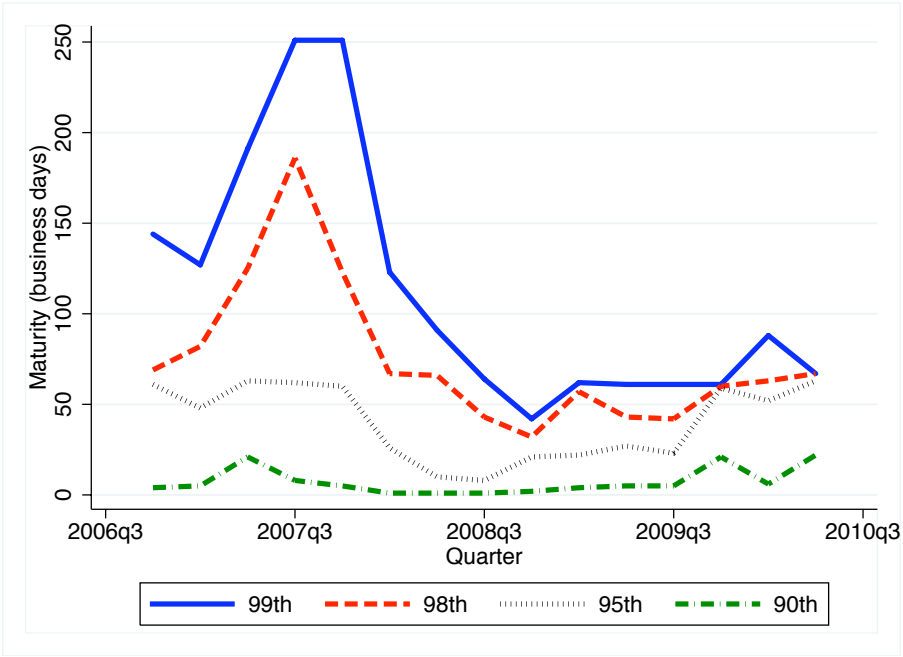


Figure 5: Percentiles of Repo Maturities

B. Haircuts

Figure 6 plots the value-weighted average haircuts for different categories of collateral over the sample period. Since MMF file their SEC reports at different month-ends throughout each quarter, we can calculate these averages at a monthly frequency. The line for private-label ABS has a gap from late 2008 to late 2009, as this type of collateral completely disappeared during this period (see Figure 3). It is apparent that haircuts for private-sector collateral increased significantly from 2007 to 2010 from around 3-4% to about 5-7% for corporate debt and private-label ABS. The similarity of haircut time series for private-label ABS and for corporate bonds until the collapse of Lehman Brothers in September 2008 suggest that, at least until that point in time, the problem was more generalized and not something specific to securitized assets. All of these patterns are suggestive of cash investors' desire to avoid risk/illiquidity in their repo loans.

An important observation from this data is that the patterns in haircuts that we observe in the tri-party repo market appear different from the bilateral interdealer repo haircuts reported in Gorton and Metrick (2011).[10] First, in Gorton and Metrick's data average haircuts are frequently zero in 2007 for corporate debt and securitized products, while the MMF repos in our data always have average haircuts of at least 2%, even for Treasuries and Agency debt. Second, although our value-weighted averages (which is the most relevant measure of aggregate funding conditions) are difficult to compare with the equal-weighted averages in finer categories reported in Gorton and Metrick (2011), an informal comparison suggests that haircuts in tri-party repos of MMF increased much less than the haircuts in their interdealer repo data (Gorton and

[10]While our findings on haircuts are at odds with Gorton and Metrick (2011), they are similar to Copeland, Martin, and Walker (2010).

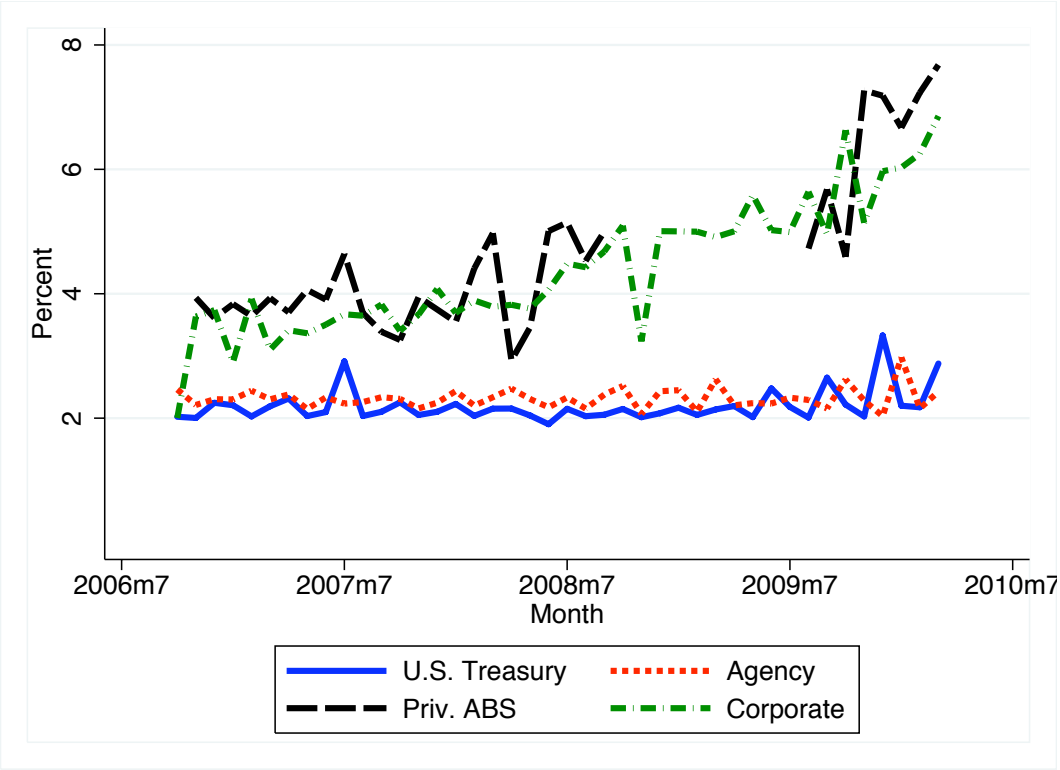


Figure 6: Haircuts by Collateral Type (weighted by notional value)

Metrick report average haircuts in excess of 50% for several categories of corporate debt and securitized products).

Taken together with our findings of the relatively small amounts of MMF repos against private-label ABS collateral, these observations suggest that the "run on repo" may have had a more modest effect on aggregate funding conditions for the shadow banking system than what one may guess from the enormous increase in haircuts for securitized products in the bilateral interdealer repo market as reported by Gorton and Metrick (2011). The model in Section I.B suggests that the higher bilateral haircuts may reflect a credit crunch driven by weak balance sheets of dealers, rather than a direct symptom of a "run on repo".

Finally, there are some surprising patterns in this data. First, the increase in

haircuts does not revert following the peak of the financial crisis in 2008. Haircut levels in 2010 are still as high, or even higher than at the end of 2008. Second, average haircuts for Agency collateral remained the same as those for Treasury obligations, despite the troubles of Fannie Mae and Freddie Mac during the summer of 2008.

C. Repo Rates

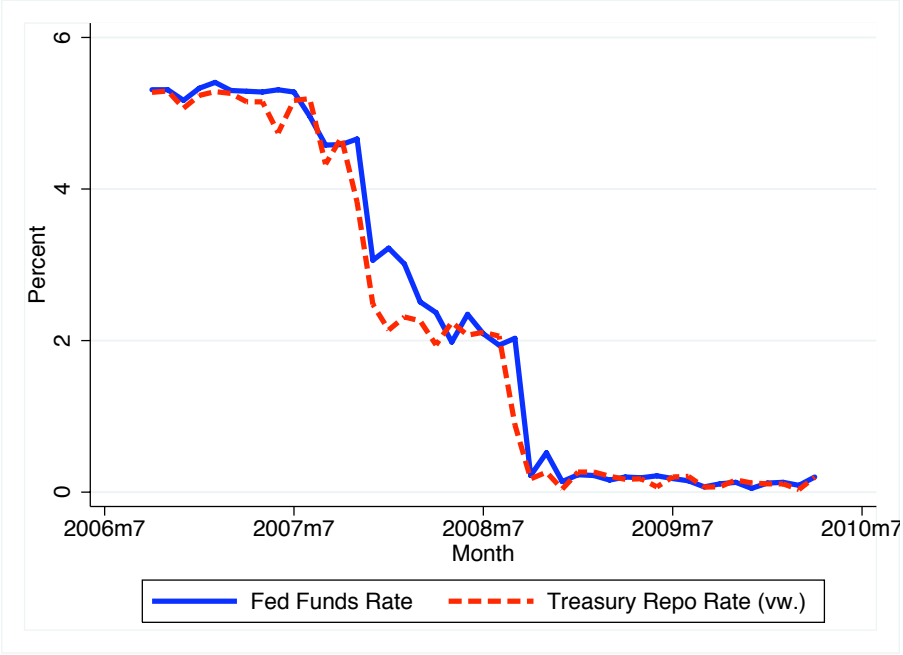
Figure 7 presents time-series of value-weighted average overnight repo rates (weighted by notional amounts). As a benchmark for comparison, we use the Federal Funds rate as a default-free rate proxy.[11]

As shown in Panel (a) of Figure 7, the average overnight repo rate for Treasury collateral typically tracks the Fed Funds rate quite closely, but there are some striking deviations. Starting in 2007, the repo rate on Treasuries drops below the Fed Funds rate. This wedge reaches a maximum of almost 100bps in 2008Q1. It is apparent that Treasuries as a class represented preferred collateral, and as Treasury collateral was scarce, the repo rates on this collateral fell substantially below other risk-free benchmarks. Note that the repo rate here is the general collateral repo rate and not the "special" collateral repo rate as discussed in Duffie (1996). Indeed, this evidence is more consistent with Krishnamurthy and Vissing-Jorgensen (2012) who argue that Treasuries as a class command a collateral/liquidity premium. Fleming, Hrung, and Keane (2010) investigate the low Treasury repo rate phenomenon in detail and show that the implementation of the Term Securities Lending Facility (TSLF) in March 2008, in which the Federal Reserve lent Treasury securities against non-Treasury collateral, helped to reduce the repo premium on Treasuries.

There is substantial variation in the repo rate by category of collateral, as evidenced

[11]The Federal Funds rate is an overnight rate and as such almost free of default risk.

(a) Average Overnight Treasury Repo Rate and Fed Funds Rate



(b) Average Overnight Repo Rate in Excess of Fed Funds Rate

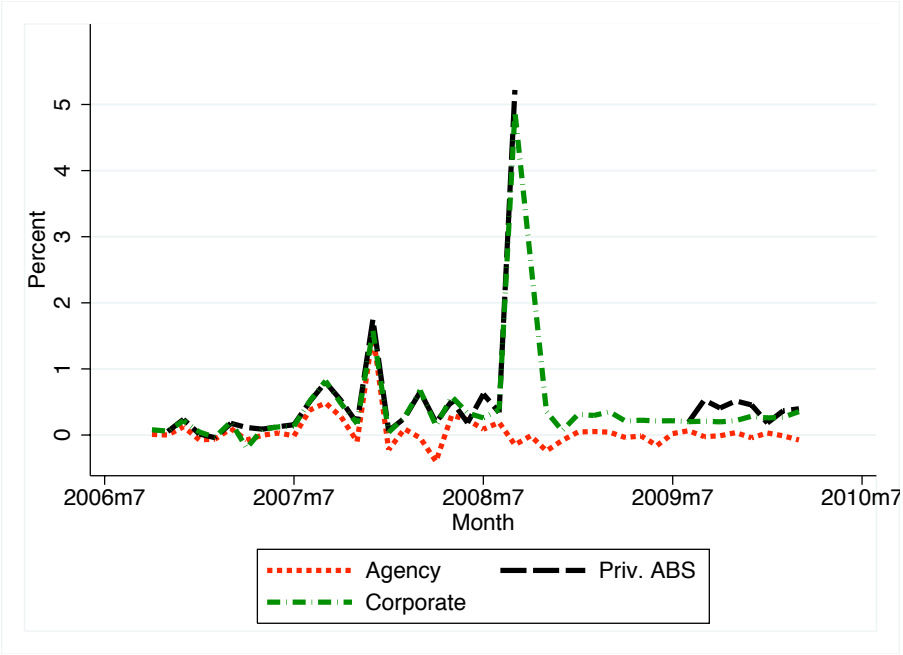


Figure 7: Average Repo Rates (weighted by notional value)

in Panel (b) of Figure 7. The spread between the Fed funds rate and the repo rate for Agency debt, corporate debt, and private-label ABS increased from close to zero in 2007 to almost 200bps in 2008Q1. The higher rates are consistent with cash investors' desire to avoid lending against risky/illiquid collateral and scarcity of Treasury collateral around the time of the Bear Stearns collapse. The spread drops after the introduction of the TSLF in March 2008, but it spikes again in September 2008 following the collapse of Lehman Brothers. Private-label ABS collateral was almost absent at that time, but a small volume of repo transactions took place at an average repo rate spread to Treasury collateral of around 500bps. Corporate debt collateral commanded a similar spread. In contrast, repo rates for Agency debt did not increase.

A final observation from this data is that unlike haircuts in Figure 6, these repo rate spreads have reverted to near pre-crisis levels as financial markets normalized in 2009 and 2010. It is noteworthy that quantities and haircuts on some asset classes have continued to reflect stress conditions. A possible explanation is that market participants' assessment of the risks of private debt instruments was permanently changed by the financial crisis.

VI. Cross-sectional Patterns by Repo Counterparty

We now turn to evaluating another channel through which the repo contraction may have contributed to the crisis. While the contraction in repo was relatively insignificant for shadow bank funding in aggregate, its effects may have been amplified if the contraction disproportionately affected key institutions. This section presents some data that is supportive of this channel. It is also possible that some dealer banks may have been perceived as more prone to default than others, which may have led cash lenders

to run on repo of these banks, irrespective of the type of collateral offered. To shed light on these issues, we examine how the contraction in repo funding with private collateral played out in the cross-section of counterparties, and whether different counterparties faced different repo terms (haircuts, repo rates) around the peak of the financial crisis. Since we only have cross-sectional data by counterparty for MMF repos, but not for SL repos, a caveat is that the following analysis only captures a partial picture of the total repo funding flows from non-banks to dealer banks.

A. Changes in Repo Quantities by Counterparty

Dealer banks that were most reliant on repo funding for private collateral in the pre-crisis period should be expected to have been more affected by the crisis. To measure their pre-crisis reliance on private collateral repo funding we focus on the period prior to the rescue of Bear Stearns in March 2008 as this was the time just before repo volumes with private collateral started to contract. Since each MMF files holdings reports only every three months, we sum up the repo funding amounts per counterparty over three month windows.[12] For each counterparty, we calculate the pre-Bear Stearns (BSC) amounts of repo with different collateral types by summing MMF repos over the three months from December 2007 to February 2008. The latter date is when repo funding with private collateral starts to contract (see Figure 4). We then compare these numbers with the repo funding post-Lehman (LEH) (September 2008 to November 2008).

Figure 8 shows how repo funding contracted or expanded for each repo counterparty

[12]Otherwise one would run into the problem that a counterparty might finance Treasuries with one MMF that files the holdings, say, at the end of February and private-label MBS with a different MMF that files holdings at the end of January. Looking at the repo funding amounts in February would yield a misleading picture in this case.

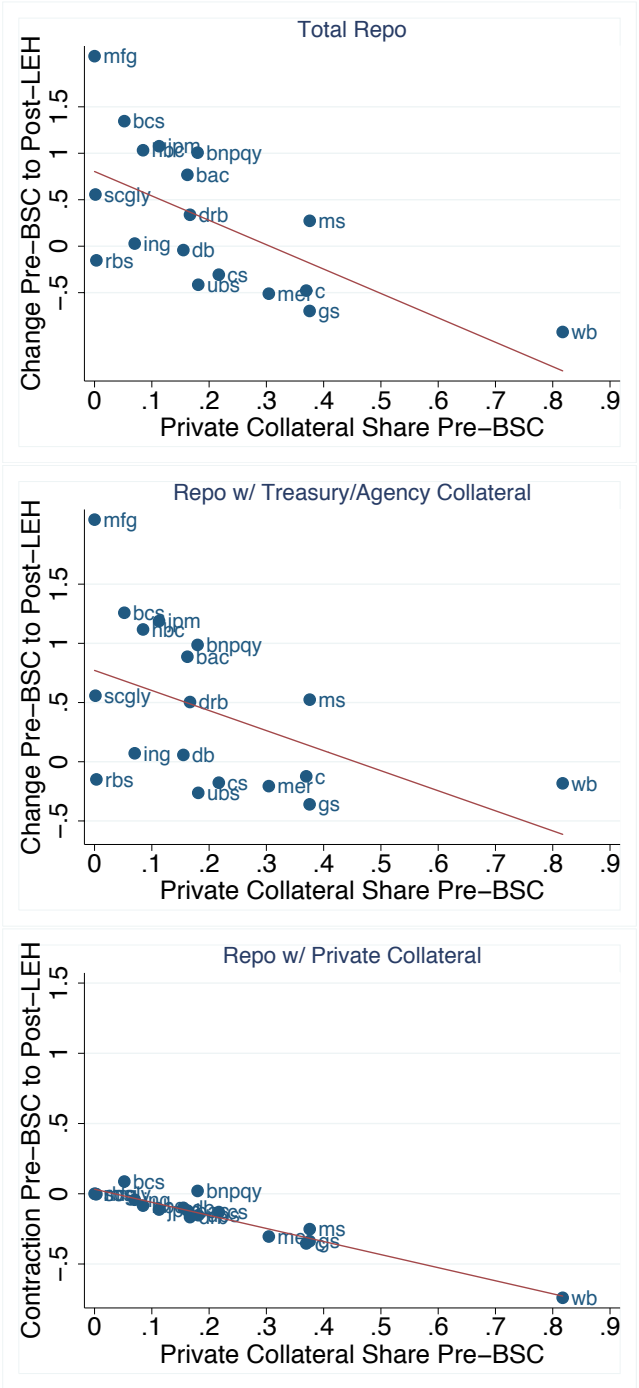


Figure 8: Contraction/Expansion in MMF Repo from Pre-Bear Stearns (Dec. 07 to Feb. 08) to Post-Lehman (Sep. 08 to Nov. 08). Change expressed as share of total MMF repo in pre-Bear Stearns period (Dec. 07 to Feb. 08).

in our data from the pre-BSC period to the post-LEH period, where the change is expressed as a fraction of each counterparty's total repo funding from MMF in the pre-BSC period. Bear Stearns and Lehman Brothers are not included in this plot, as we cannot compute their post-LEH repo funding, but further below we will show data on their private collateral shares in the pre-BSC period. The top panel plots the change in total Repo funding against the pre-BSC private collateral share. The figure shows that there was substantial heterogeneity in reliance on private debt instruments as repo collateral. Mizhuo (MFG), Royal Bank of Scotland/Greenwich (RBS), Societe Generale (SCGLY), Barclays (BCS) have private collateral shares of close to zero, while Merrill Lynch (ML), Morgan Stanley (MS), Goldman Sachs (GS), and Citigroup (C) have private collateral shares of almost 50%. Wachovia (WB) is an outlier with a private collateral share above 80%. The change in total repo funding from the pre-BSC to the post-LEH period is negatively correlated with the private collateral share in the pre-BSC period. Total repo funding expanded for most counterparties, but it contracted for many of those that had relatively high private collateral shares before the financial crisis reached its peak.

The two panels below break the change in total repo funding into the change in repo funding with Treasury and Agency collateral (middle) and the change in repo funding with private collateral (bottom). They show that the change in total repo funding has two drivers: (a) repo funding with Treasury and Agency collateral expands for most counterparties, except those with high pre-BSC private collateral shares; (b) repo with private collateral disappears almost completely for all counterparties (which leads to a regression slope of approximately -1.0 in the bottom panel).

Figure 9 shows that the counterparties with the highest private collateral shares in the pre-BSC period are also more likely to be among those that had the highest

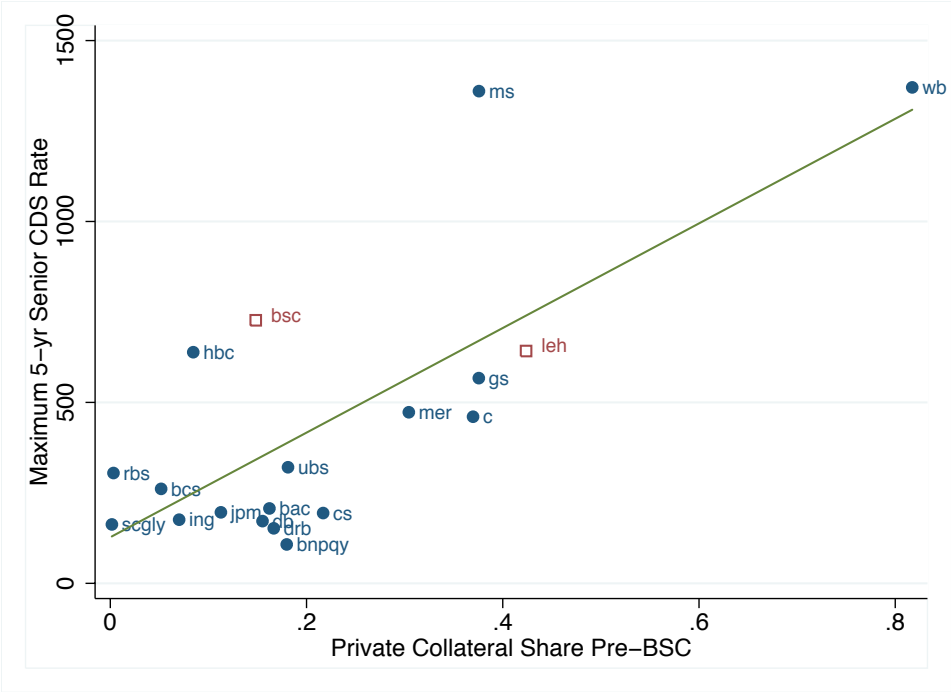


Figure 9: Maximum CDS Rates After Lehman Brothers Bankruptcy Plotted Against Private Collateral Share in MMF Repo during the Three Months Prior to Bear Stearns Rescue (December 2007 to February 2008). Maximum of CDS rates between day of Lehman Brothers bankruptcy (September 15, 2008) and end of year 2008. Bear Stearns' and Lehman Brothers' CDS rates in this plot are the maximum CDS rates prior to rescue/failure. The regression line has a slope of 1445 with t-statistic 4.57.

perceived default risk around the peak of the financial crisis, as measured by each counterparty's maximum 5-year CDS rate in the time period following the bankruptcy of Lehman until the end of 2008. To illustrate where Lehman and Bear Stearns are located in terms of their private collateral share, the plot also includes these two counterparties with their CDS rate set to the maximum value attained at any time prior to the rescue or bankruptcy.

Even though the counterparties with the highest pre-BSC private collateral shares were perceived as most at risk to default, Figure 8 shows that these counterparties did not generally reduce the amount of repo with Treasury and Agency collateral.

Morgan Stanley, the counterparty with the second highest perceived default risk at the end of September 2008 and the third highest private collateral share in the pre-BSC period, even increased its amount of repo funding with Treasury and Agency collateral substantially. While these findings are subject to the caveat that we only observe MMF repos, and not repos with SL and other cash providers, they are suggestive that repo funding with high-quality collateral remained available even for dealer banks with high perceived default risk.

Some accounts of the failure of Bear Stearns and Lehman suggest that these dealer banks did indeed experience difficulty in rolling over repo on all forms of collateral, but only in the last days before failure. This is not captured in our low-frequency MMF repo data. Copeland, Martin, and Walker (2010) present daily data on Lehman's tri-party repo book in September 2008 and document that the total amount of repo funding started to contract substantially only a few days prior to Lehman's bankruptcy filing. They show that the contraction affected all collateral categories, including Treasury collateral.

B. Repo Terms by Counterparty on September 30, 2008

Funding difficulties of dealer banks with high perceived default risk, even if not apparent in repo quantities, could also manifest themselves as a worsening of the price-terms of repo agreements. For this reason, we also examine cross-sectional variation in haircuts and repo rates of different counterparties and find that most of the variation is due to the type of collateral rather than the credit risk of counterparties. This finding further reinforces our conclusion that funding problems at some dealer banks are driven by a lack of high-quality collateral (and a contraction of repo loan supply for low-quality collateral) rather than a general reluctance of repo lenders to extend credit to high-risk

counterparties. We again focus our analysis on the end of September 2008, the time when dealer banks faced the most adverse funding conditions.

For the purpose of this analysis, we refine our categorization of collateral to deal with some ambiguity in classification of Treasury and Agency collateral. We create an additional mixed Treasury/Agency category for cases in which we cannot cleanly classify the collateral as Treasury or Agency securities. This includes cases, for example, in which the collateral is a portfolio of Treasury and Agency securities. In these cases, we had so far assigned the collateral type that has the highest number of counts in the list of securities comprising the collateral portfolio. But this means that some variation in repo rates within a category could be driven by collateral portfolio composition rather than the characteristics of the repo counterparty. This ambiguity is not significant when Agency and Treasury collateral commands very similar terms in repos, but on September 30, 2008 it could be significant. We further put all non-Treasury, non-Agency collateral into a private collateral group. On September 30, 2008, this group includes almost exclusively corporate bonds or corporate equities.

The top graph in Figure 10 plots the (value-weighted) average haircuts of each counterparty, against the CDS rate for 5-year senior debt on September 30, 2008. It is apparent from these figures that average haircuts vary by collateral type, but within collateral categories, they are virtually identical for different counterparties, irrespective of the CDS rate. The bottom graph plots the (value-weighted) repo rate against the CDS rate. While there is some variation in repo rates within collateral categories, this variation is not correlated with the CDS rate of the counterparty.

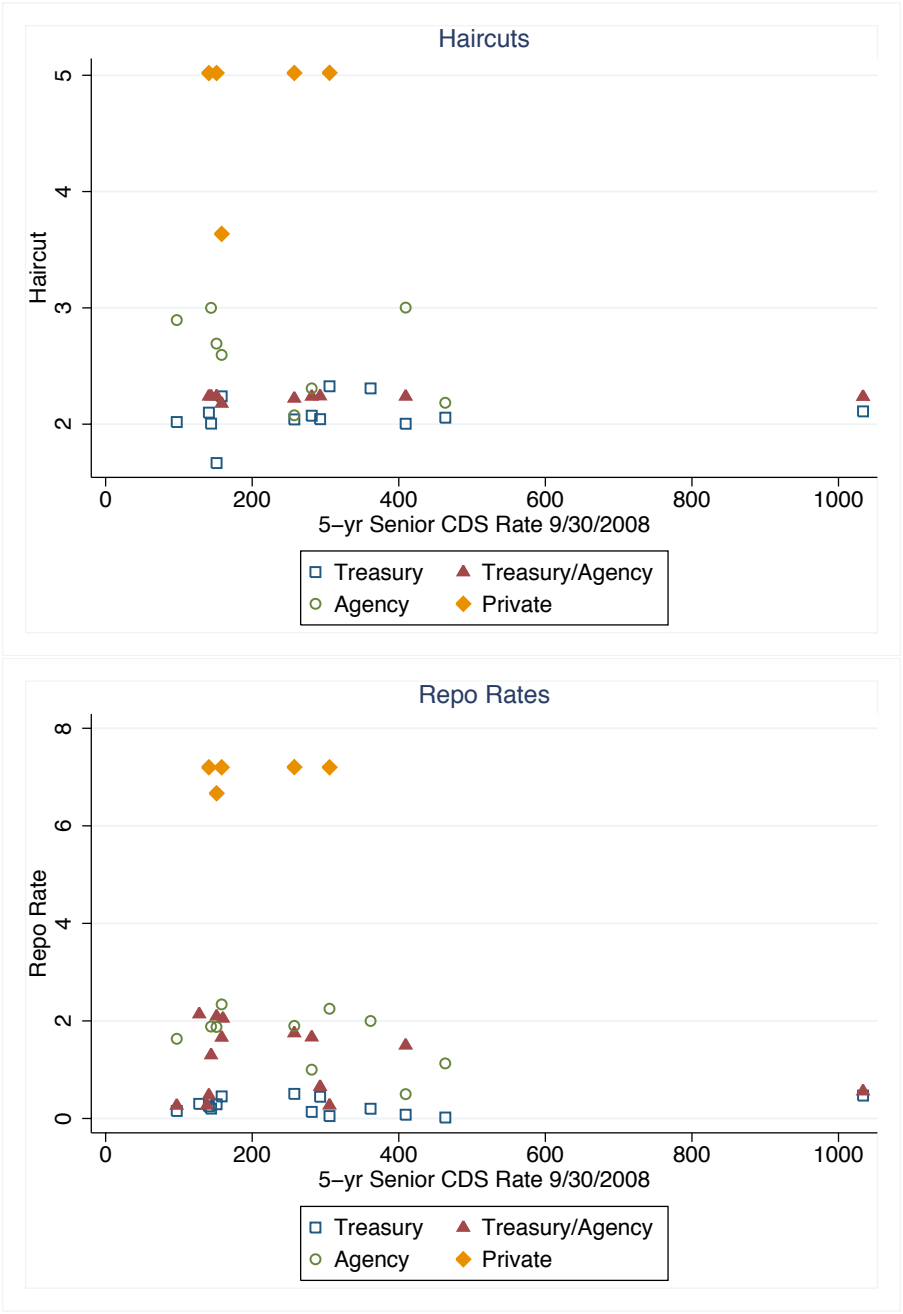


Figure 10: Overnight Repo Rates and Haircuts on September 30, 2008. Value-weighted averages per counterparty

VII. Federal Reserve Programs

Any evaluation of repo quantities during the financial crisis also must take into account that the the Federal Reserve initiated a series of funding programs, beginning in 2008Q1, that partly replaced private-sector repo lending. While these programs were intended to offset the reduction in private sector funding of the shadow banking sector, it is also possible that these programs attracted some repo borrowers that would have been able to access private markets. We are not able to establish the counterfactual, i.e., the hypothetical amount of repo lending that would have taken place in private markets in the absence of the Fed's programs, but we can shed light on the extent to which these programs did in fact offset the private contraction in aggregate, and the level of individual dealer banks. We also compare the terms of the Fed facilities versus market terms.

A. Quantity of Fed Funding

We focus on four principal programs:

1. PDCF (Primary Dealer Credit Facility), March 2008: Loan facility that provided funding to primary dealers in exchange for any tri-party-eligible collateral.[13] Loans were overnight, and made at the primary credit discount rate.

2. TSLF (Term Securities Lending Facility), March 2008: Facility to loan Treasuries from the Fed's portfolio in exchange for investment-grade collateral.[14] Loans were 28-day, and rates were set in an auction.

[13]Before September 14, 2008, the collateral was restricted to investment grade securities (Adrian, Burke, and McAndrews (2009))

[14]Before September 17, 2008 the range of eligible collateral was more restricted (Fleming, Hrung, and Keane (2009))

3. Maiden Lane I and III, various dates: Fed made loans to SPVs that held private-label ABS. Facilities were set up in conjunction with interventions in Bear Stearns and AIG.

4. CPFF (Commercial Paper Funding Facility), October 2008: Fed made loans to an SPV to purchase 3-month ABCP.

We omit Maiden Lane II, because this SPV acquired assets from AIG's securities lending business that were, prior to the crisis, funded with cash collateral that AIG obtained in securities lending transactions, which means that these assets were not funded with repo prior to the crisis. Maiden Lane III, in contrast, purchased ABS not from AIG, but from dealer banks to whom AIG had sold credit protection on these ABS. These dealer banks may have financed these ABS holdings with repo, and so we include Maiden Lane III.

The top plot in Figure 11 aggregates the private-label ABS repos of MMF and SL along with the funding on these securities that came from the Fed through PDCF, TSLF, and Maiden Lane I and III.[15] The figure shows that Fed programs offset a considerable portion of the contraction in repo funding starting in 2008Q1. As a result, total funding smoothly decreases during the subsequent quarters. The bottom plot in Figure 11 presents the same data for corporate bond repos. The Fed programs were used much less in this case. But, the private sector funding contraction is also not as severe.

Figure 12 presents the data for ABCP. The private sector funding contraction was quite gradual and the CPFF was not as used. We should also add that a significant portion of the assets from the ABCP funded SPVs were taken back onto commercial

[15]The split of SL repo between corporate debt securities and private-label ABS is calculated under the assumption that the split (in terms of percentage) is the same as for MMF repos.

(a) private-label ABS

(b) Corporate Debt

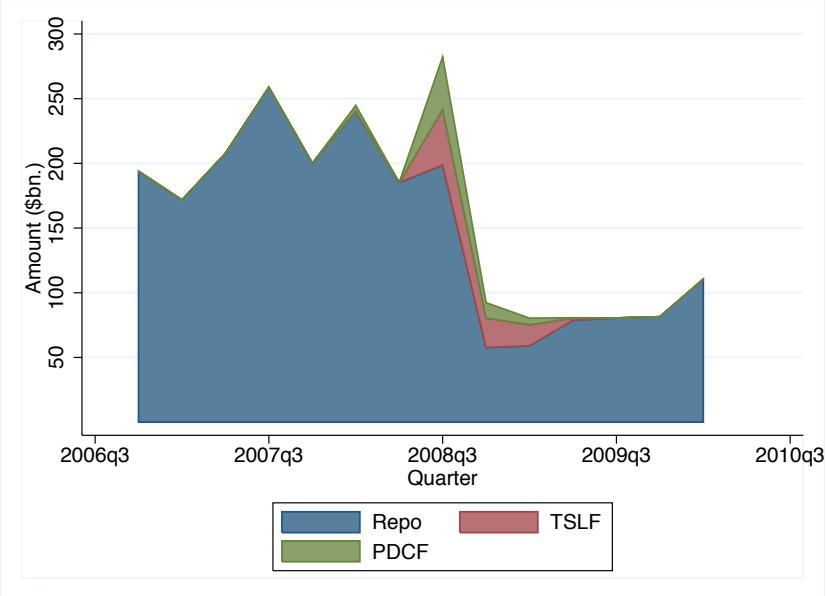


Figure 11: Repo and Federal Reserve (TSLF and PDCF) funding of Private Sector Assets

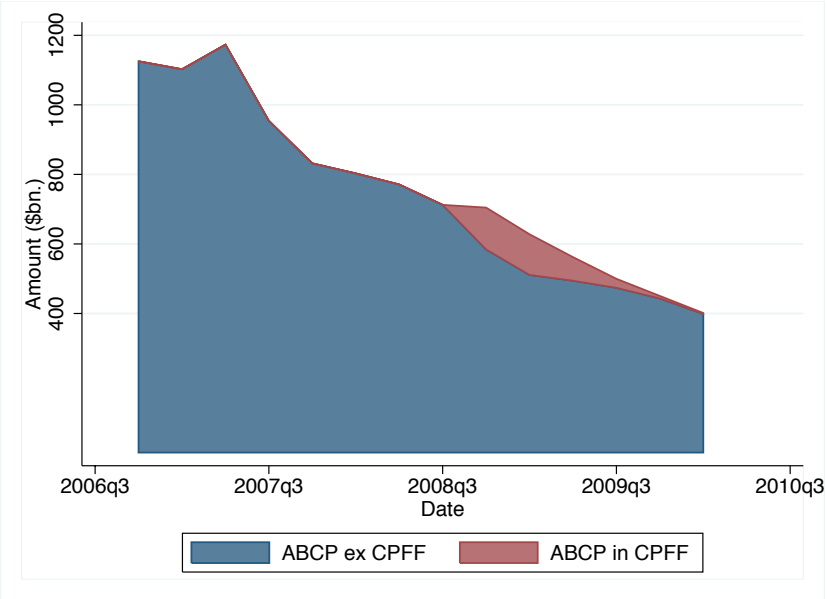


Figure 12: ABCP oustanding (ex CPFF) and Federal Reserve (CPFF) funding

bank balance sheets. Commercial banks had access to alternative funding sources including FDIC insured bank deposits and FDIC insured bond issues (see He, Khang, and Krishnamurthy (2010)). With such alternatives it may be that the CPFF was not as needed as the facility directed to dealer banks.

B. Fed Program Participation, by Dealer Bank

Where did the dealers with high pre-BSC private collateral shares turn for financing? Column (2) in Table IV shows that part of the answer is that the Fed provided the funding through the TSLF. In schedule 2 TSLF auctions, dealer banks could bid with investment-grade securities as collateral to obtain Treasury securities on loan against a fee. The dependent variable in column (2) measures the extent to which a dealer bank utilized the maximum amount that it was allowed to borrow under schedule 2 in the two schedule 2 auctions just before and after 9/30/08 (9/25/08 and 10/1/08).

For each auction, we take the ratio of the loan amount awarded to a dealer bank to the maximum possible award, and we average this ratio across the two auctions. We regress this dependent variable on the agency collateral share and the private collateral share prior to the Bear Stearns rescue (pre-BSC, December 2007 to February 2008). As the regression results show, dealer banks with a high private collateral share tend to max out their borrowing capacity under schedule 2.

The regressions in columns (1) and (2) also show that dealer banks with a high Agency collateral repo share in the pre-BSC period are more likely to max out their borrowing capacity under both schedules in the TSLF. Moreover, column (3) shows that the total amount of borrowing under the TSLF on 9/30/08 is positively related to both Agency and private collateral shares in the pre-BSC period. Thus, only dealer banks with high pre-BSC Treasury collateral shares do not resort much to the TSLF (which is sensible, as the purpose of the TSLF was to exchange non-Treasury collateral against Treasuries).

C. Fed versus Market, Program Terms

The TSLF terms appears cheaper than market terms. For example, the schedule 2 auction on 10/1/08 yielded a (uniform) loan fee of 1.51%. As the TSLF exchanges non-Treasury collateral against Treasuries, the relevant comparison here is the spread between Treasury repo rates and repo rates for non-Treasury collateral. Figure 10 shows that the spread for private collateral on 9/30/08 was approximately 7%.[16] Thus, the TSLF rate of 1.51% appears subsidized relative to market conditions at the time. For Agency collateral, the comparison between the schedule 2 auction and the private

[16]Private collateral on this date included a substantial amount of corporate equities, which was not eligible as TSLF collateral. However, the average repo rates for corporate debt and corporate equities were virtually identical on this date.

Table IV: Fed Program Utilization by Primary Dealers in September 2008

For each dealer bank, we have two explanatory variables: Agency share pre-BSC is the proportion of MMF repos with Agency collateral in the three-month period prior to the rescue of Bear Stearns (December 2007 to February 2008). Private share pre-BSC is the share of corporate debt, private-label ABS, and other non-Treasury, private-label collateral in the pre-BSC period. Dependent variables are defined as follows: For the TSLF, maxout1 denotes average utilization of maximum available borrowing under TSLF schedule 1 (Treasury and Agency collateral) in the two schedule 1 auctions closest to 9/30/08 (9/18/08 and 10/2/08), maxout2 is defined accordingly as the average utilization in schedule 2 auctions (9/25/08 and 10/1/08), while Total refers to the total notional amount of Treasury securities borrowed from the TSLF (in $bn) on 9/30/08. PDCF Total is the total amount borrowed from the PDCF (in $bn) on 9/30/08. We report t-statistics in parentheses.

	TSLF			PDCF
	maxout1	maxout2	Total	Total
	(1)	(2)	(3)	(4)
Agency Share pre-BSC	1.43	0.77	46.16	9.34
	(2.21)	(1.58)	(2.31)	(0.62)
Private Share pre-BSC	-0.36	1.10	39.33	57.85
	(-0.48)	(1.92)	(1.66)	(3.26)
Observations	15	15	15	15
Adjusted R^2	0.17	0.28	0.36	0.42

market rates is less clear-cut. The spread of Agency repo rates to Treasury repo rates in Figure 10 is often below 1.51%. However, there is a more clear-cut distinction when comparing the schedule 1 auction, which accepted Agency but not private collateral, to the private repo market. The schedule 1 auction on 10/2/08 yielded a (uniform) loan fee of 0.42%, which is lower than most of the Agency repo spreads in Figure 10. How can we understand the differences in these Fed and market terms, especially where the Fed terms are set in a competitive auction? It is possible that the differences are due to measurement problems and not comparing repo terms on exactly identical assets. However, it is also possible that these differences are reflective of a stigma attached

to TSLF borrowing. Indeed, as we discuss next, it is fairly clear cut that the PDCF carried such a stigma.

Some dealers with a high pre-BSC private collateral share maxed out their funding under TSLF. Where did they fund their excess private collateral? As we know from Figure 8, they did not obtain further repo funding from MMF with this type of collateral. Column (4) of Table 10 provides the answer: They turned to the PDCF. The amount borrowed from the PDCF is strongly positively correlated with the pre-BSC private collateral share. Unlike the TSLF, dealer banks with high Agency collateral shares however avoided the PDCF even though funding rates were attractive for private collateral (2.25% on 9/30/08), and all collateral eligible for tri-party repo funding was also eligible for borrowing under the PDCF. This is consistent with the view that borrowing from the PDCF was viewed as carrying a stigma similar to the stigma associated with discount-window borrowing from the Fed (on which the PDCF was modeled). Borrowing from the PDCF seems to be viewed as a last resort that dealer banks try to avoid at possibly high cost. For example, Lehman Brothers did not access the PDCF in the week prior to its bankruptcy filing (Valukas (2010)).

D. Summary

Overall, these findings reinforce the conclusion that the problem of repo was one of funding private collateral. Any heterogeneity in funding conditions among dealer banks was driven by the type of collateral held by the banks. The dealers with high private collateral shares found themselves in difficulty not because of a run on a counterparty per se, but because getting repo financing with private collateral became expensive. To avoid high financing costs in the repo market, dealer banks with high private collateral shares turned to the TSLF and PDCF. Dealer banks with low private collateral shares,

in contrast, avoided the PDCF, despite the attractively low rates charged in the PDCF relative to market rates at the time, which was likely due to a discount window stigma.

VIII. Conclusion

We examine data on the repo lending by money market funds and securities lenders to understand the role of repo in the demise of the shadow banking system, and as a factor in the financial crisis. Money market funds and securities lenders provide the majority of repo funding to the shadow banking system. During the financial crisis, repo funding collateralized by private-label securitized assets contracted sharply. This aspect of the data is consistent with the "run on repo" that has been prominently emphasized by Gorton and Metrick (2010a, 2011, 2010b). However, repo accounts for only a small fraction of the short-term funding of securitized assets in the shadow banking system prior to the crisis. This finding does not support the broadbrush picture painted by Gorton and Metrick that the expansion of repo drove the growth of the shadow-banking system and the subsequent run on repo caused its collapse. The short-term funding of securitized assets through ABCP and direct investments by money market investors is an order of magnitude larger than repo funding, and the contraction in ABCP is an order of magnitude larger than the run on repo. Short-term debt played an important role in the expansion and collapse of the shadow banking sector, but, in aggregate, repo was a sideshow relative to ABCP.

While small in aggregate, the run on repo may have contributed to the crisis through an alternative channel: Troubles in funding securitized assets with repo may have been a major source of problems for some systemically important dealer banks that were most heavily exposed to these assets. We find that dealers with a high share of

private securities in repo collateral were the most vulnerable, and most likely to access emergency programs of the Federal Reserve. The troubles of dealer banks also provide an explanation for the divergence between the terms of the MMF-to-dealer repo in our data (in which haircuts rise only moderately), and the interdealer repo in Gorton and Metrick's data (which show dramatically rising haircuts): Raising haircuts can be a response by balance-sheet constrained dealers to their own lack of capital and liquidity.

Overall, the problems in the repo market during the crisis look less like the analogue of a traditional bank run by depositors and more like a credit-crunch in which dealer banks tightened the terms for their borrowers. Our findings also underscore that it is important to distinguish between non-bank to dealer repo lending (which is a source of net funding for the shadow banking system) and interdealer repo (which reallocates liquidity within the shadow banking system). More research is needed to better understand the role of interdealer repo markets in the dynamics of shadow banking.

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Appendix

A. Money Market Mutual Fund SEC Filings Data

Table A.I lists the fund families for which we have collected repo data as of the time of this writing, along with the CIK numbers under which their portfolio holdings reports are filed with the SEC. Often the reports of many or all money market funds of a family are filed under the same CIK number. In other cases (e.g., Dreyfus), the reports are filed under different CIK numbers.

The most difficult part of the data collection is the classification of collateral. Typically, the holdings reports provide a brief description of the collateral underlying the repo agreement, such as "U.S. Treasury Securities", or a list of specific securities (in terms of maturity, coupon rate, and issuer). In some cases, the portfolio of securities underlying a repo agreement can be a mix of different types of securities. The most common case of mixed collateral involves Treasury securities mixed with Agency bonds or Agency-backed MBS. private-label backed ABS or corporate bonds are only very rarely mixed with Treasuries and Agency securities. Except in rare cases, the filings do not report the portfolio weights. To approximate the portfolio weights, we count the number of securities in the list of securities in the portfolio, and we assign portfolio weights based on the relative number of times a collateral type is mentioned in this list. For quantity calculations, we split the notional value of a repo agreement with a portfolio of collateral based on these portfolio weights. For calculations involving repo terms by collateral, we assign the collateral type that has the highest number of counts in the list of securities.

Some fund families (e.g. Goldman Sachs and Fidelity) have the funds in their family pool much of their repo investments in a joint account. For these joint accounts, the filings report a list of counterparties to the repos in this joint account, but only one repo rate for the whole account, and only the total collateral amount for the whole joint account, while notional values are listed by counterparty. We assign the single repo rate and the same haircuts to all counterparties to the repos in this joint account.

B. Risk Management Association Securities Lender Data

Some securities lenders do not participate in the RMA survey in some quarters (see table A.II. Participants are marked with "x"). The biggest worry in this regard is about the non-participation of State Street in some of the surveys. State Street's cash collateral reinvestments amount to more than $0.5 trillion, and so omission of State Street would substantially understate the role of securities lenders. For this reason, we

Table A.I: Sample of Money Market Fund Families

Fund family	CIK numbers
AIM/Invesco	842790, 828806, 205007
Blackrock	97098
Columbia	1097519, 751200, 1477434
Dreyfus	1171061, 819940, 717341, 871967, 312564, 885409, 831363, 878092, 863471, 814236, 865440, 779128, 885408, 30158, 30160, 846421, 759667, 820482, 740766, 878092, 315783, 1038520, 1423799, 315668, 871967, 863510, 1449014, 867955, 312564, 831363, 814236, 878734, 863558, 779128, 740123, 796251, 843781
DWS	353447, 858372, 862157, 55189, 703642, 88047, 863209
Evergreen	820636, 1046233
Federated	856517, 852495
Fidelity	278001, 35315, 276516, 356173, 704207, 917286
First American	356134
Goldman Sachs	822977
JP Morgan	1217286, 763852
Morgan Stanley	1227155, 93285, 859037, 356409
Northern	916620, 710124
Oppenheimer	836423, 312538, 1358587, 74673
Reserve	83335
Schwab	857156
UBS	225732, 780403, 1060517, 868055, 930007, 703876, 703875, 944684, 1403166
Vanguard	106830, 891190, 783401, 821404, 788599, 862341, 788606
Wells Fargo	1081400
Western	747576, 889512, 850628

impute State Streets' cash collateral reinvestment position (marked with "e" in Table A.II). We collect the total cash collateral reinvestment amount from State Street's 10-K and 10-Q filings, and we assume that State Streets cash collateral is invested in the same way as the aggregate cash collateral portfolio of the securities lenders that participate in the RMA survey in a given quarter. A comparison of the portfolio allocations in adjacent quarters in which State Street does and does not participate does not reveal any substantial shifts in allocations. This indicates that State Streets portfolio allocation is unlikely to be very different from the allocation of other securities lenders.

Table A.II: RMA Survey Participants

	2006	2007				2008				2009				2010
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1
AIG Global Investment Corp	x	x	x	x	x	x	x							
Mellon Fin. Corp./Bank of New York Mellon	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Barclays Global Investors	x	x	x		x		x	x	x		x	x	x	x
Boston Global Adv./Goldman Sachs Agcy. Lend.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Brown Brothers Harriman & Co.	x	x	x	x	x	x	x			x	x	x	x	x
Citibank, N.A.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Comerica Bank			x	x	x	x	x	x	x	x	x	x	x	x
Credit Suisse	x		x	x	x	x	x	x						
Dresdner Kleinwort	x						x							
Frost National Bank	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Investors Bank & Trust Company[1]	x	x												
JPMorgan Chase & Co.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
M & I Global Securities Lending	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MetLife Insurance Company		x												
The Northern Trust Company	x	x	x	x	x	x	x	x	x	x	x	x	x	x
PFPC Trust Co./PNC Global Inv. Serv.		x		x			x	x	x	x	x	x	x	x
State Street[2]	e	e	e	e	e	e	x	e	x	x	x	x	x	x
U. S. Bank, N.A.	x	x		x	x		x	x	x	x	x	x	x	x
Union Bank of California, N.A.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
The Vanguard Group, Inc.	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Wachovia Global Securities Lending	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Wells Fargo Institutional Investments	x	x	x	x	x	x	x	x	x	x	x	x		

[1] Acquired by State Street.

[2] Entries labeled "e" indicate quarters in which State Street did not participate in the RMA survey, and in which we obtain the total amount of cash collateral from State Street's 10-K/10-Q filings, and we estimate State Street's allocation of this cash collateral to different assets under the assumption that the allocation is the same as the allocation reported in the RMA for survey participants.