

Repo runs: Evidence from the tri-party repo market ^{*}

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Abstract

This paper provides a detailed description of the U.S. tri-party repurchase market, a key source of short-term funding for securities dealers and a market that played an important role in the recent financial crisis. The institutional details of this market are first explained. Then using confidential data from July 2008 to January 2010, the authors provide a quantitative account of the tri-party repurchase market during the financial crisis. We document that the level of haircuts and the amount of funding were surprisingly stable in this market, even for securities dealers who suffered adverse shocks. A notable exception is Lehman Brothers, for which we document a sudden and rapid decrease in collateral financed in the tri-party repurchase market. The stability of haircuts in the tri-party repurchase market contrasts with evidence from the bilateral repurchase market, in which haircuts increased sharply (as shown in Gorton and Metrick (2011)).

Keywords: Tri-party repo, Wholesale funding, Short-term funding

JEL classification: E44, E58, G24

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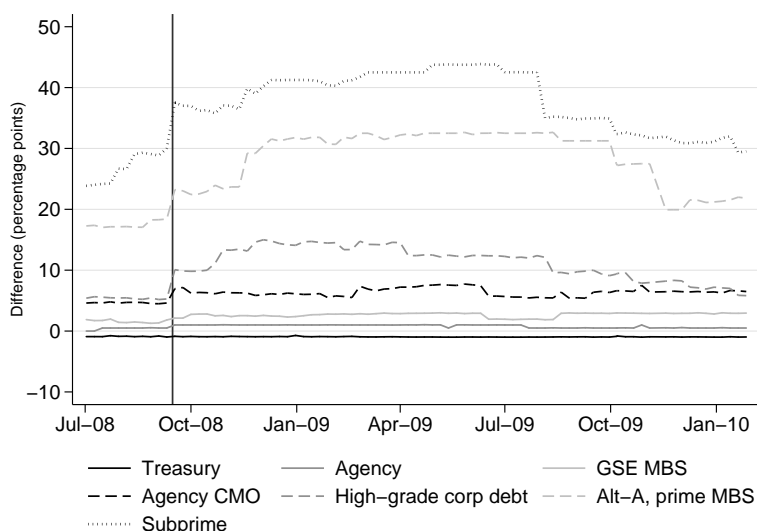
1 Introduction

The US tri-party repurchase (repo) market serves as a key source of short-term funding for securities dealers, is critical for secondary market liquidity in Treasuries and other securities, and plays an important role in the pricing and price discovery of cash and derivatives instruments. Given its stature, it is not surprising that the U.S. tri-party repo market played a significant role in the recent financial crisis. The problems experienced by Bear Stearns and Lehman Brothers, for example, were associated with a large and precipitous decrease in their tri-party repo funding. Yet within the research community, little is known about this crucial market.

This paper takes a first step at filling this hole in the literature. First, we provide a detailed description of the tri-party repo market: describing the main actors and the timing of the market on a typical day, as well as reporting summary statistics. Second, we provide a quantitative account of the market's evolution from July 2008 to January 2010. We study the behavior of haircuts and values of collateral posted over this period and document the surprising result that securities dealers' funding was remarkably stable. Strikingly, even around times when a securities dealer experienced adverse shocks, we show the affected dealer is able to maintain its funding without changes in haircuts. While haircuts do vary by dealer and asset class, haircuts and quantities for a dealer-asset class pair change little in response to changes in a dealer's default risk (as measured by its credit-default swap spread). The notable exception is Lehman Brothers. Days before the holding company declared bankruptcy, the broker-dealer entity experienced a dramatic fall in the amount of funding it obtained in this market. While our data does not cover this period, anecdotal evidence suggests that the experience of Bear Stearns was similar (e.g., see Friedman (2010)).

In addition to describing events within the U.S. tri-party repo market, our results provide an interesting contrast between the behavior of haircuts in the tri-party repo market and in other segments of the repo market, as documented by Gorton and Metrick (2011). Gorton and Metrick study data from a high-quality dealer trading with other high-quality dealers in a bilateral repo market and show that haircuts increased dramatically, similar to the "haircut

Figure 1: Differences in Haircuts for Overnight Repos between the Bilateral and Tri-Party Repo Markets



Note: Difference in medians calculated as the bilateral repo haircut median minus the tri-party repo haircut median for each asset class. Vertical black line corresponds to Lehman Brothers' bankruptcy.

spirals” modeled in Brunnermeier and Pedersen (2009) (see also Adrian and Shin (2010)). In this sense, the bilateral repo market appears to have suffered from a generalized run. In the tri-party market, however, haircuts for all but the lowest-quality collateral changed very little. Even for low-quality collateral, the increase in haircuts was much less pronounced than in the bilateral market. Figure 1 shows the differences in the average haircut for overnight repos between a segment of the bilateral market and the tri-party repo market. We discuss this figure in more detail later in the paper but note here that the increase in the spread between the haircuts in these two markets is almost entirely driven by an increase in bilateral repo haircuts. Furthermore, these spreads are sizable for high-grade corporate debt (over 10 percentage points in 2009) and enormous for Alt-A and subprime collateral (over 30 percentage points in 2009).

The different behavior of haircuts across these two markets is puzzling. The bilateral and tri-party repo markets are similar along several important dimensions. For example, the con-

tractual details of the repurchase agreements are similar in both markets and a large subset of similar collateral is posted in both markets.¹ Market participants note that both markets are used by financial firms for funding purposes and the larger securities dealers often re-hypothecate collateral obtained in the bilateral repo market to the tri-party repo market. Consequently, it is noteworthy that haircuts, an important feature of any repo contract, behaved so differently across these similar and connected markets.

Understanding the different use of haircuts across these two repo markets is important to policy makers. This is especially true when considering policies designed to prevent runs on securities dealers, given the potential role of haircuts as an equilibrating mechanism to lower the probability of runs on institutions (Martin, Skeie, and von Thadden 2010). At the end of this paper we discuss this issue. We highlight what we believe are the important differences across the tri-party and bilateral repo markets and argue that these differences imply different “run dynamics” in these two repo markets. Unlike the bilateral market, which appears to have suffered from what Gorton and Metrick describe as a generalized run, our evidence suggests that in the tri-party repo market, investors withdrew funding from specific institutions.

Our paper is related to Gorton and Metrick (2011), who study a segment of the bilateral repo market. We have data from another segment of the bilateral market, which behaved in a similar manner. We are also able to compare haircuts between the bilateral and the tri-party repo markets. Krishnamurthy, Nagel, and Orlov (2011) have data on the investments of money market mutual funds and securities lenders. Both of these types of investors represent a large share of cash invested in the tri-party repo market. Consistent with our paper, their study shows that funding appears mostly stable in the tri-party repo market, although they provide evidence of a sharp reduction in the amount of non-agency mortgage-backed securities (MBS) and asset-backed securities (ABS). This decline, which occurred before the beginning of our sample, could be interpreted as a generalized run on that particular asset class. Because our data are not limited to money market mutual funds and securities lenders, we are able to more

¹See Adrian, Bego, Copeland, and Martin (2011) for a detailed description of the various segments of the U.S. repo market.

completely document the dealers' funding positions in the tri-party repo market, starting in July 2008.

2 The tri-party repo market in the United States

In the United States, a tri-party repo is a form of repo for which a third party, called the clearing bank, provides clearing and settlement services to the cash investor and the collateral provider.² Tri-party repos are popular in part because of the efficiency gains associated with the services provided by the clearing bank.

2.1 Main actors in tri-party repo

Three main actors operate in the U.S. tri-party repo market: collateral providers, cash investors, and the clearing banks.

Collateral providers borrow cash from the cash investors and secure the transaction by posting collateral. Primary dealers, who are banks or securities broker-dealers that can trade directly with the Federal Reserve, supply the majority of collateral in the tri-party repo market.³ Other dealers, some large hedge funds, and other institutions with large portfolios of securities also participate in the tri-party repo market, but they represent a small share of the total volume. We use the terms collateral providers and dealers interchangeably in this paper.

Dealers enter the tri-party repo market for at least two reasons. First, they seek to economize on their use of capital and so prefer to borrow cash to purchase the securities they hold (Tuckman 2010). In turn, the securities can serve as collateral to obtain cash, providing one way in which securities dealers can obtain leverage.⁴

²Appendix C in Copeland, Martin, and Walker (2010) defines and provides a brief overview of repos. See also Garbade (2006).

³For more information on primary dealers, see <http://www.newyorkfed.org/markets/primarydealers.html>.

⁴Consider the stylized example of a dealer with \$1 billion in capital. This dealer can use its capital to buy \$1 billion in securities and repo these securities to obtain cash. If the haircut on the repo is 5 percent, the dealer can get \$950 million in cash. With this cash, the dealer can buy new securities and repo them out to get more cash.

Second, dealers provide intermediation services to clients seeking cash, for example in their role as prime brokers to hedge funds. Such services are often provided through a repo transaction, in which the dealer extends cash to the client against collateral. This collateral can be rehypothecated in the tri-party repo market, provided the client allows it.

The second set of actors is the cash investors, which are more numerous and diverse than the set of collateral providers.⁵ Money market mutual funds represent between a quarter and a third of the cash invested in the tri-party repo market, while securities lenders represent another quarter. Securities lenders use the tri-party repo market to re-invest the cash collateral they receive when they lend securities.⁶

According to FRBNY (2010), the top ten dealers finance about 85 percent of the value of tri-party repo securities, while around 65 percent of the cash invested in tri-party repo is provided by the top ten cash investors. The largest individual dealers regularly finance more than \$100 billion in securities, and over \$400 billion during the market's peak. The largest cash investors individually provide daily tri-party repo financing in excess of \$100 billion.

The third set of actors is the clearing banks: JPMorgan Chase and the Bank of New York Mellon. The clearing banks play an important role as provider of clearing and settlement

Assuming the same haircut, the dealer can get an additional \$902.5 million in cash in that way. Continuing this process, the dealer can obtain a portfolio of securities worth \$20 billion with its \$1 billion in capital. The formula to find the value of the portfolio of securities is: $1 + 0.95 + 0.95^2 + \dots = \sum_{i=0}^{\infty} 0.95^i = \frac{1}{1-0.95} = 20$. This example provides an upper bound, as it assumes that the dealer is fully leveraged, which is not generally the case.

⁵Investors are single firms but can include the securities lending division of a bank as well as the asset management division. Similarly, a money market mutual fund complex is considered a single investor.

⁶In the United States, a security cannot be sold short by an institution that does not borrow the security to make delivery, an activity also known as "naked" short selling (SEC regulation SHO, see <http://www.sec.gov/divisions/marketreg/mrfaqregsho1204.htm>). The ban on naked short selling creates an important role for securities lending, which allows an institution that wants to sell a security short to borrow it. Custodial banks often provide the service of lending the securities of their clients. In the United States, most securities lending is done against cash collateral. Hence, securities lenders usually have large pools of cash that they seek to re-invest, on behalf of their clients. While investment strategies for these pools of cash may differ, they often resemble the investment strategies of money market mutual funds. This is in part due to the fact that many securities lending deals are "open," meaning that the lenders must return the cash collateral to the borrower as soon as that borrower returns the security. Hence, the securities lender is exposed to "redemption requests" that are somewhat similar to pressures faced by money market mutual funds.

services. They take custody of securities used as collateral in a tri-party repo transaction, they value the securities and make sure that the specified haircut is applied, they settle the transaction on their books, and they offer services to help dealers manage the use of their collateral.⁷ The tri-party repo clearing banks do not match dealers with cash investors, nor do they play the role of brokers in that market.

The clearing banks act as an agent to the collateral providers and the cash investors in all the roles noted above. In the U.S. tri-party repo market, the clearing banks also play the role of principal because they finance the collateral provider's securities during the day.⁸ We describe the timing that leads to this extension of credit in the next section.

2.2 Timing of events

This section describes the timing of events in the tri-party repo market. This description focuses on market practice before the proposed reforms announced on May 17, 2010.⁹ A particularly important step in the timing of a repo is the morning unwind, described below, which contributes to the fragility of this market.

2.2.1 Morning: Trade agreement

A cash investor and a collateral provider typically agree on a tri-party repo before 10 a.m. Anecdotal evidence suggests that at least 90 percent of a dealer's tri-party repos are arranged before that time. The agreement specifies the amount of cash the investor will provide, the interest rate, the term of the repo, and the acceptable collateral.

⁷Each of these roles is considered in more detail in Copeland, Martin, and Walker (2010).

⁸One of the goals of the the Task Force on Tri-Party Repo Infrastructure is to sharply reduce the amount of intraday credit extended by the clearing banks in this market (http://www.newyorkfed.org/prc/report_100517.pdf). Copeland, Duffie, Martin, and McLaughlin (2011) discuss policy issues related the the U.S. tri-party repo market.

⁹The report of the Task Force on Tri-Party Repo Infrastructure is available at http://www.newyorkfed.org/prc/report_100517.pdf. The Federal Reserve Bank of New York released a white paper commenting on the report and describing the weaknesses in that market. The white paper is available at http://www.newyorkfed.org/banking/nyfrb_triparty_whitepaper.pdf.

The majority of tri-party repos are believed to be overnight or “open” repos. Open repos roll over by default, unless one of the parties explicitly chooses to cancel the transaction. The haircut that applies to a particular collateral class is not negotiated at the trade level but, instead, is specified in the appendix of the custodial undertaking agreement between the three parties. Hence, changing haircuts requires amending the agreement. A trade agreed in the morning does not settle until the afternoon, around 6 p.m.

2.2.2 Afternoon: Collateral allocation

In the afternoon, after the close of Fedwire[®] Securities Service and the Depository Trust Company (DTC), the collateral provider knows the composition of its portfolio. With this information, and with the information provided by the cash investors on the amount of financing they will provide and the securities they will accept as collateral, the dealers can allocate acceptable collateral to each trade. The clearing banks provide tools to make sure that only collateral acceptable to the investor gets allocated to repos and to guarantee that the haircut specified in the custodial agreement applies.¹⁰

The settlement of the initial leg of the repo trade occurs on the books of the clearing banks in the afternoon. Balances are transferred from the investor’s to the collateral provider’s balances account, while securities are transferred from the collateral provider’s to the cash investor’s securities account.

2.2.3 Next morning: The “unwind”

Between 8 and 8:30 a.m. the next morning, the clearing banks “unwind” tri-party repo trades. The unwind consists of sending the balances back to the investor’s balances account and the securities back to the collateral provider’s securities account on the books of the clearing bank. At the same time, the clearing banks extend intraday credit to the dealer since the securities are no longer financed by the tri-party investors.

¹⁰Copeland, Duffie, Martin, and McLaughlin (2011) provides more details on this collateral allocation process.

All repos, including term repos and open repos that are rolled over, are unwound. Term trades are “rewound” every evening, at the same time as the initial leg of new repos is settled, but not necessarily with exactly the same collateral. Reallocating collateral for term trades could be desirable even if the repos were not unwound. The tri-party repo is considered “general collateral” financing, meaning that an investor may care about the class of collateral it receives but not about the specific issue. Hence, the collateralization of a trade could vary from day to day or even intraday, as the dealer’s portfolio of securities changes.

The unwind is necessary because collateral providers need access to their securities during the day to satisfy delivery obligations and because the clearing banks had not previously invested in systems that would allow substitution of collateral in a repo. As part of the Task Force reforms, the clearing banks plan to offer collateral substitution services.

Dealers often keep securities that are not financed through tri-party repos in custody at the clearing bank. The clearing banks employ a risk management concept called net free equity to ensure that the value assigned to the dealer’s securities on their books exceeds the value of the intraday loan. Using net free equity, the clearing banks can allow dealers to buy and sell securities in an operationally efficient manner.

2.3 Empirical description

The Federal Reserve Bank of New York collects data on the tri-party repo market. The data to which we have access include the quantity and type of collateral posted in this market and the haircuts associated with various types of collateral. These data are not the universe of dealers and investors, but rather all the major players that account for the vast majority of tri-party repo activity. For each dealer, we observe the daily total value of collateral posted and the amount of posted collateral associated with the haircut, by collateral class. For example, we observe that dealer X posted \$102 billion of agency MBS on January 1, 2009, as collateral and that \$2 billion of that collateral is for the haircut. Hence, we can deduce that dealer X borrowed \$100

billion in cash, securing that loan with \$102 billion in agency MBS.¹¹

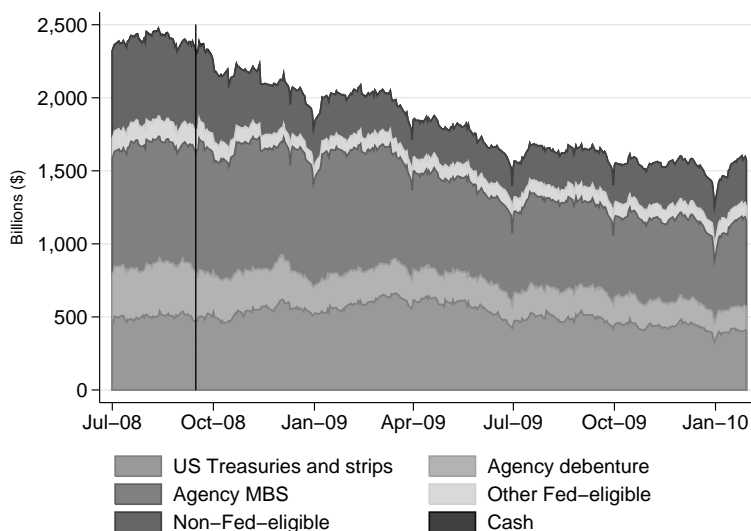
For investors, we have the data in two different forms. For one clearing bank, denoted clearing bank A, we know the joint distribution of collateral and investors. For each investor, we observe the daily total value of collateral accepted by asset class, including the haircut and excluding accrued interest. For the other clearing bank, denoted clearing bank B, we know the joint distribution of investors and dealers. For each dealer, we observe the daily total amount of cash lent by investors. Both the investor and the dealer data are at a daily frequency, from July 1, 2008 to January 27, 2010.¹²

Our data begin after the fall of Bear Stearns but before the Lehman Brothers' bankruptcy. Before Lehman declared bankruptcy, almost \$2.5 trillion worth of collateral was posted in the tri-party repo market each day. This number is slightly down from a historic high of \$2.8 trillion in April 2008 (FRBNY 2010). After Lehman Brothers declared bankruptcy, collateral posted in this market fell gradually until about July 2009, after which the amount of collateral posted in the tri-party repo market stabilized at a level slightly above \$1.5 trillion (see figure 2). This decline is also seen in the amount of collateral posted after taking out haircuts and is thus not a product of haircuts changing over time. We believe the decline in collateral posted in tri-party repo reflects a number of outside processes, rather than reflecting problems with the tri-party repo market itself. These include a general deleveraging by dealers in response to the financial crisis, runoff caused by maturing assets and a decline in new issuance, declines in valuations that reduced the size of dealers' portfolios, and the removal of agency MBS

¹¹The collateral valuations include accrued interest, and thus our calculations of cash borrowed will be overstated by the amount of accrued interest. This is a tiny amount, however, especially because we are considering a period of very low interest rates.

¹²The General Collateral Finance (GCF) repo market, a blind-brokered interdealer market run by the Fixed Income Clearing Corporation (FICC), settles in the tri-party repo market. Depending on the question, including GCF repos along with regular tri-party repos could be considered double-counting. In the investor data, we observe GCF repos and so can remove these observations when appropriate. In the dealer data, however, we do not observe a breakdown between GCF and regular tri-party repo deals. Starting after our data end, the Tri-Party Repo Infrastructure Reform Task Force publishes snap shots of the tri-party repo market, including statistics on the nominal value of GCF repos (<http://www.newyorkfed.org/tripartyrepo/index.html>). In May 2011, the total amount of securities delivered to the FICC for GCF repos was \$171.6 billion.

Figure 2: Tri-Party Repo Market Size (\$ billions of collateral)



Note: July 17, 2008 excluded due to missing data from one clearing bank. Vertical line represents Lehman Brothers' bankruptcy.

securities through the Federal Reserve's Large Scale Asset Purchase program.¹³ Given that the quantity of collateral posted in the tri-party repo market stabilized during the summer of 2009, we divide our sample into two periods. We denote from July 2008 to June 2009 as the "crisis" period and from July 2009 to January 2010 as the "stable" period.

Across these two periods, the composition of collateral posted in tri-party repo did not change much (see table 1). Over three-quarters of all collateral posted over the whole sample are composed of highly liquid securities, such as U.S. Treasuries, agency MBS, and agency debt. The next-largest asset class, corporate bonds, maintains a share of just over 5 percent of the market. However, the comparison between the stable period and the crisis period does obscure a substantial fall in non-Fed-eligible collateral.¹⁴ As seen in figure 2, there was about

¹³Background on the Large Scale Asset Purchase program can be found at http://www.newyorkfed.org/markets/funding_archive/lsap.html.

¹⁴Fed-eligible securities are securities that can be settled on the Fedwire® Securities Service, while Non-Fed eligible, also called DTC-eligible, can be settled by the Depository Trust Company.

Table 1: Composition of Tri-Party Repo Collateral (percent)

		Crisis	Stable	All
Fed-eligible collateral	Agency Debentures	12.6	11.4	12.2
	Agency MBS	37.4	36.3	37.1
	Agency Remic	4.1	4.6	4.2
	Ginnie Mae MBS Pools	0.9	1.2	1.0
	Ginnie Mae REMICs	0.3	0.3	0.3
	U.S. Treasuries and Strips	26.8	29.0	27.4
	<i>sub-total</i>	82.1	82.7	82.2
Non-Fed-eligible collateral	Asset-Backed Securities	2.2	2.4	2.2
	Commercial Paper	0.4	0.3	0.4
	Corporate Bonds	5.5	5.9	5.6
	DTC-Other	0.1	0.4	0.2
	Equity	4.1	4.0	4.1
	Money Market	1.3	1.6	1.4
	Municipal Bonds	0.9	0.7	0.9
	Other	0.1	0.1	0.1
	Private Label CMO	2.7	2.0	2.5
	Whole Loans	0.7	0.1	0.5
<i>sub-total</i>	18.0	17.5	17.9	

Note: “Crisis” is the period from July 2008 to July 2009, “Stable” is from July 2009 to January 2010 and “All” covers both sample periods. Fed-eligible securities are securities that can be settled on the Fedwire[®] Securities Service, while non-Fed eligible, also called DTC-eligible, can be settled by the Depository Trust Company.

\$600 billion non Fed-eligible collateral in July and August of 2008. Starting around September 2008 (the same month Lehman Brothers declared bankruptcy), the amount of non Fed-eligible collateral posted in tri-party repo steadily fell until the first quarter of 2009, when it leveled out at around \$300 billion.

From July 2008 to January 2010, there were 32 dealers active in our sample, a large number of which were primary dealers. Even within our sample of the larger dealers in tri-party repo, the dealer side of the market is quite concentrated, with the top five dealers accounting for 57 percent of collateral posted and the top 10 accounting of 86 percent. We separate dealers into two categories: “large” dealers with a daily average of more than \$50 billion in posted collateral, and “small” dealers with a daily average of less than \$50 billion. On average, “large” dealers provide about \$140 billion of collateral each day, using 11 different types of collateral, while “small” dealers provide \$10 billion using six types of collateral.

We find that large dealers tend to borrow from a number of investors. Using the investor data from clearing bank B, we find that the top five dealers of that clearing bank borrow from an average of 53 investors each. Yet dealers still rely significantly on specific investors: for the top five dealers, the largest investor’s share of a dealer’s overall borrowing is 19 percent. Not surprisingly, smaller dealers borrow from fewer investors. The median number of investors for the five dealers who borrow the smallest amounts is one. It should be noted that the composition and characteristics of dealers differ across clearing banks, so that the behavior of dealers of clearing bank B may not be entirely generalizable to that of clearing bank A.

Like the dealer side, there is concentration on the investor side, with roughly 70 percent of collateral posted being held by the largest 10 investors in our data. The largest 10 investors typically lend over \$100 billion each day, across a number of dealers.¹⁵ Using the investor data from clearing bank B, we find that the largest number of dealers to which an investor lent cash on a single day was 11. Small investors, which make up the majority of the investors in our

¹⁵To compute these numbers, we combined investors’ positions across clearing banks. This entailed adding dollars of collateral held (from clearing bank A) and dollars of cash invested (from clearing bank B). Because of haircuts, these figures are not equivalent, but for these purposes this difference is not important.

data but account for only a small fraction of the cash lent, generally lend to a single dealer. The value-weighted median number of dealers to which an investor will lend cash on a single day is six. The statistics on the number of dealers to which an investor will lend are understated, however, because they are based on data from one clearing bank and the larger cash investors are active with both clearing banks.

3 Main Empirical Findings

In this section, we analyze haircuts and the value of collateral posted in our sample. We first document how haircuts differ across collateral classes and counterparties. Further, we detail how haircuts moved very little during the recent financial crisis. Second, we analyze the value of collateral posted in this market, and document how little investors and dealers alter their repo arrangements on a daily basis. Third, we focus on events where dealers experience adverse shocks, and explore how investors reacted in the tri-party repo market.

3.1 Haircuts in tri-party repo

If the dealer defaults on its repo agreement, the collateral securing the transaction partially protects the cash investor from losses. The haircut on a repo transaction, which measures how much a repo transaction is over collateralized, is a way for a cash investor to minimize losses from liquidating collateral in the event of default.

Haircuts may differ across collateral types for a variety of reasons, including the assets' liquidity, credit risk, and the underlying price volatility of the asset. Based on conversations with market participants there seems to be agreement on a basic ordering of the "quality" of assets used as tri-party repo collateral.¹⁶ In table 2 we have ordered securities from high to low quality, according to that ordering, except for the categories DTC-other and Other. We expect to see higher haircuts associated with lower quality collateral. Note that the effect of

¹⁶An example of this ordering can be found on page 18 of the final report of the Task Force on Tri-Party Repo Infrastructure http://www.newyorkfed.org/tripartyrepo/pdf/report_120215.pdf.

the underlying price volatility of the asset on haircuts is likely dampened by the overnight maturity of most repos in this market.¹⁷

Our data confirm that haircuts differ across collateral type, and, in general, lower quality collateral commands higher haircuts relative to higher quality collateral. We list average haircuts by collateral class in table 2 for the whole sample, as well as for the crisis and stable subperiods. Indeed, securities perceived to be of high quality, such as U.S. Treasuries, agency debentures, and agency MBS, have lower haircuts relative to those securities perceived to be of lower quality, such as asset-backed securities and corporate bonds.

A second interesting point captured in table 2 is the very small changes in haircuts across the stable and crisis subperiods. Indeed, the average haircut across all collateral types is roughly equal across the two periods (see the last row of table 2). We further explore this lack of change in haircuts later in this section.

A last point focuses on the size of the standard deviations, especially for non-Fed-eligible collateral. These statistics suggest that different dealers have to post substantially different haircuts on the same type of collateral, suggesting that counterparty risk may play a role in the setting of haircuts.¹⁸

To better illustrate the variance in haircuts by counterparty, we plot median haircuts by dealer and collateral class in figure 3. In the figure, each dealer is randomly assigned a number consistent across asset classes. For example, dealer 20 has an average haircut of about 117 for both private label collateralized mortgage obligations (CMO) and asset-backed securities. Two features of figure 3 stand out. First, dealers face substantial heterogeneity in haircuts, even for highly liquid assets such as U.S. Treasuries. Second, some dealers face high haircuts relative to their peers across all asset classes. While the use of collateral to secure loans can

¹⁷While we lack maturity information in our data, industry contacts consistently report that the largest tenor in this market is, by far, overnight. For example, FitchRatings Fund & Asset Manager Rating Group reports in its Money Market Funds U.S.A. Special Report (Oct. 4, 2010) that 81.8 percent of repo allocations by Fitch-Rated taxable money market funds as of August 31, 2010, were overnight.

¹⁸The standard deviation on “Other” collateral is enormous. This collateral class includes a wide variety of collateral which are not comparable over time. Consequently, the statistics on the mean and standard deviation of this collateral class are hard to interpret, but are included for completeness.

Table 2: Tri-Party Repo Haircuts: Mean and Standard Deviation

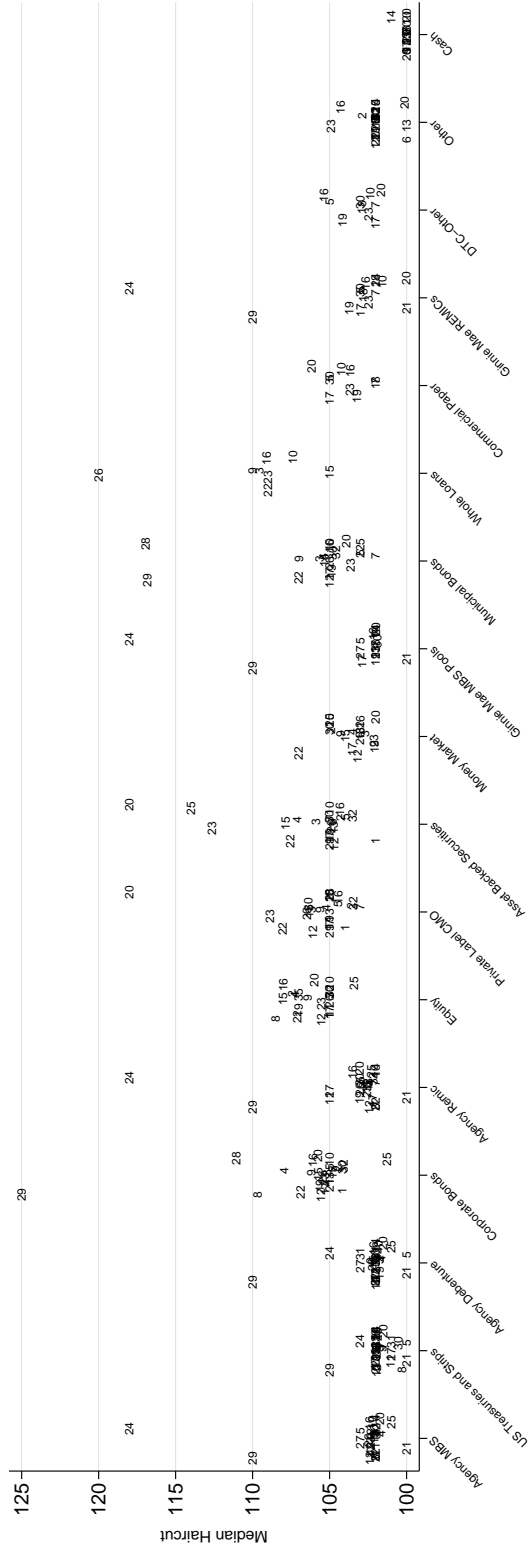
		Crisis		Stable		All	
		mean	sd	mean	sd	mean	sd
Fed-eligible collateral	U.S. Treasuries and Strips	101.7	0.59	101.8	0.42	101.7	0.54
	Ginnie Mae MBS Pools	102.0	0.42	101.9	0.23	102.0	0.36
	Ginnie Mae REMICs	102.5	1.09	102.2	1.18	102.4	1.12
	Agency Debentures	101.9	0.49	101.9	0.39	101.9	0.47
	Agency MBS	102.3	0.60	102.0	0.40	102.2	0.56
	Agency Remic	103.1	1.31	102.6	0.53	103.0	1.14
Non-Fed-eligible collateral	Money Market	103.8	1.29	104.1	1.19	103.9	1.26
	Commercial Paper	104.2	1.75	103.9	0.63	104.1	1.57
	Corporate Bonds	106.2	2.80	106.0	1.71	106.1	2.50
	Equity	106.3	1.57	108.5	2.28	107.0	2.08
	Municipal Bonds	107.7	7.74	105.3	3.76	107.1	7.04
	Private Label CMO	106.3	2.83	105.9	3.43	106.2	2.99
	Asset-Backed Securities	107.1	3.90	105.8	1.73	106.7	3.40
	Whole Loans	108.7	1.16	108.3	4.74	108.7	1.58
	DTC-Other	103.0	1.34	103.6	1.34	103.3	1.38
Other	104.3	76.9	102.3	1.03	103.8	66.47	
All		102.8	3.98	102.7	2.01	102.8	3.49

Note: “Crisis” haircuts are computed over July 2008 to July 2009, “Stable” haircuts over July 2009 to January 2010, and “All” haircuts over both sample periods. “sd” is standard deviation. Average haircuts are computed using the value of the collateral as weights. Fed-eligible securities are securities that can be settled on the Fedwire® Securities Service, while non-Fed-eligible, also called DTC-eligible, can be settled by the Depository Trust Company.

be thought of as a mechanism for minimizing counterparty risk, this figure nonetheless shows that differences among dealers is an important factor in the setting of haircuts.¹⁹

¹⁹An additional item of note is that haircuts on cash collateral are not zero for all dealers. Cash is sometimes included in a tri-party repo if a dealer does not have enough securities to pledge as collateral, for example, because fails were higher than expected. Cash would then make up the difference between the value of the available securities and the amount of the repo. The fact that the haircut on cash is not always zero may be due to investors that assign the same haircut to all asset classes, consistent with the idea that some investors do not actively manage haircuts. It could also be the result of cash not being a perfect security. Perfecting a security means that a party has taken the legal steps necessary to establish a lien against the security. This is straightforward with noncash collateral but more difficult to accomplish with cash collateral. Consequently, investors could charge a nonzero haircut in hopes of discouraging the use of cash collateral. In practice, cash collateral is rarely used in tri-party repo.

Figure 3: Median Dealer Haircuts by Asset Class



Note: Two median haircuts, associated with the same dealer, of 126 and 135 for private label CMO and asset-backed securities, respectively, are not shown. Each dealer is assigned a number consistent across asset classes. The asset classes are ordered from left to right by total volume over the sample.

We analyze the degree to which differences in assets or dealers are driving the level of haircuts by regressing haircuts on dummies for asset classes and for dealers and then compare the estimated coefficients (see table 3). The coefficient estimates for dealers and collateral class have been ranked from smallest to largest. The dealer coefficients range from 1.1 to 14.7, quite a wide range.²⁰ But the three largest estimated coefficients look like outliers and in fact these three are small dealers. Ignoring the three largest estimated coefficients, the coefficients on the dealer dummy variables range from 1.1 to 3.8. By comparison, the coefficients on the collateral class dummy variables range from 0.1 to 6.9. Strikingly the estimated coefficients on agency debenture and agency MBS are not statistically different from zero, and hence, holding all else equal, offering Treasuries (the excluded asset class), agency debt, or agency MBS as collateral is estimated to not impact the haircut a dealer faces.²¹ These findings suggest that the counterparty in a tri-party repo is a main driver in setting haircuts. Given the existence of collateral, the importance of counterparty risk may seem surprising, but it has been highlighted by market participants. For example, “Craig Delany, a managing director at JPMorgan’s Investment Bank ... stated that, in triparty repos, typically investors look to the counterparty (i.e., broker dealer) first and the collateral second when setting haircuts. In other words, a haircut may not be sufficient for an investor if it has serious concerns about the viability of its counterparty” (Valukas 2010).

This regression also highlights the lack of movement in haircuts over time. In our sample of 85,246 observations, this regression, which captures only simple means effects, is able to explain 31 percent of the variation in haircuts, because average haircuts are remarkably stable in our sample (see figure 4). For the three asset groups that make up the majority of collateral posted in this market—Treasuries, agency debentures and agency MBS—haircuts hardly moved

²⁰The coefficients associated with dealers are all statistically significant at the 5 percent level, except for dealer 5, where the coefficient is statistically significant at the 10 percent level.

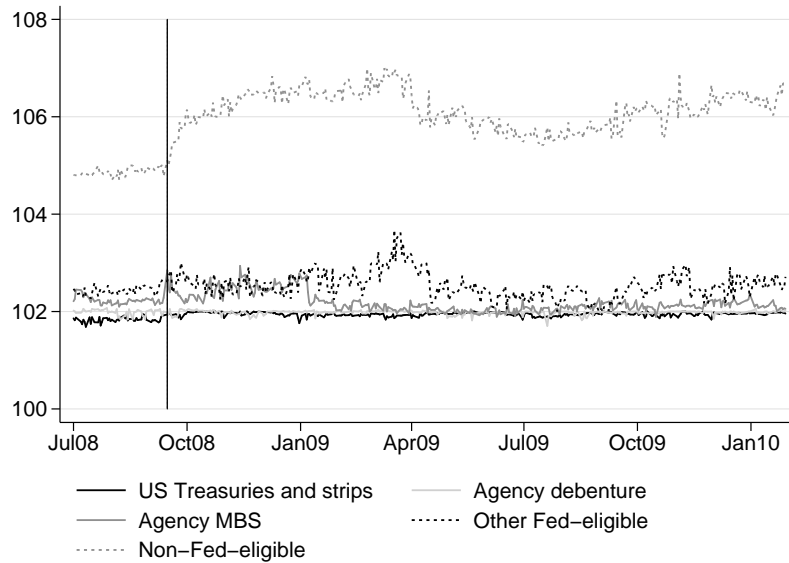
²¹Except for agency debenture, agency MBS and Ginnie Mae MBS Pools, all the coefficients associated with asset classes are significant at the 5 percent level. The coefficient for Ginnie Mae MBS Pools is statistically significant at the 10 percent level.

Table 3: Coefficients on Haircut Decomposition

Variable	Coefficient		Variable	Coefficient	
	estimate	std. err		estimate	std. err
dealer 1	1.09	0.41	Agency Debenture	0.10	0.49
dealer 2	1.12	0.44	Agency MBS	0.44	0.49
dealer 3	1.32	0.67	Ginnie Mae MBS Pools	0.89	0.39
dealer 4	1.35	0.67	Agency Remic	0.95	0.54
dealer 5	1.38	0.77	Ginnie Mae REMICs	1.48	0.47
dealer 6	1.40	0.32	DTC-Other	1.74	0.44
dealer 7	1.42	0.37	Money Market	2.16	0.47
dealer 8	1.46	0.69	Other	2.45	1.21
dealer 9	1.49	0.36	Commercial Paper	2.46	0.44
dealer 10	1.55	0.34	Municipal Bonds	3.82	0.54
dealer 11	1.58	0.66	Corporate Bonds	4.01	0.51
dealer 12	1.63	0.25	Equity	4.38	0.70
dealer 13	1.78	0.33	Asset Backed Securities	4.99	1.02
dealer 14	1.93	0.67	Private Label CMO	5.37	1.40
dealer 15	2.03	0.60	Whole Loans	6.85	0.78
dealer 16	2.08	0.30			
dealer 17	2.10	0.57	constant	99.09	0.55
dealer 18	2.14	0.40	clrbnk	0.53	0.44
dealer 19	2.31	0.31			
dealer 20	2.45	0.50			
dealer 21	2.76	0.59			
dealer 22	2.83	0.58			
dealer 23	2.84	0.54			
dealer 24	2.88	0.64			
dealer 25	2.88	0.71			
dealer 26	3.04	0.91			
dealer 27	3.77	1.34			
dealer 28	3.84	0.75			
dealer 29	9.00	1.96			
dealer 30	9.89	4.00			
dealer 31	14.69	2.15			

Note: clrbnk is a dummy variable equal to 1 for trades settled by one of the clearing banks. The dealer with the lowest average haircuts and U.S. Treasuries and Strips were the excluded dummies for dealer and asset classes, respectively. There are 85,256 observations and the R-squared for the regression is 0.31. Standard errors are clustered by dealer-asset class pair.

Figure 4: Median Haircuts by Asset Type



Note: Vertical line denotes the date of Lehman Brothers' bankruptcy filing.

over the second half of 2008.²² After the Lehman Brothers' bankruptcy, haircuts for non-Fed-eligible collateral did rise, although the increase was only, roughly, from 105 to 107. We return to this point in section 3.3, where we show that adverse shocks and changes in a dealer's riskiness (as measured by its credit default swap spread) have little effect on the haircuts a dealer faces.

As highlighted in the introduction, this lack of change in haircuts is very different from the large change in haircuts documented in Gorton and Metrick (2011) for an interdealer repo market for low-quality collateral. To further explore the difference in haircut dynamics in tri-party repo versus bilateral repo markets, we use confidential survey data on haircuts of bilateral repos from the Markets Group at the New York Federal Reserve.²³ These haircuts reflect what dealers charge their customers when they lend cash through a repo. In this segment of the repo

²²In Copeland, Martin, and Walker (2010) we provide fan charts of haircuts for four general collateral classes. Even at the 25th/75th percentile, we do not see large changes in haircuts.

²³See Fleming, Hrug, and Keane (2010) for a description of these data.

Table 4: Matching of asset classes

Dealers as cash providers (bilateral)	Dealers as collateral providers (tri-party)
Treasury	US Treasuries and Strips
Agency	Agency Debentures
GSE MBS	Agency MBS
Agency CMO	Agency Remic
High-Grade Corp Debt	Corp Bonds
Alt-A, Prime MBS	Private Label CMO
Subprime	Asset Backed Securities

market, dealers provide liquidity to hedge funds, real estate investment trusts, and banks, for example. To some extent, the securities that dealers obtain as collateral in the bilateral repo market are rehypothecated by the dealer and used as collateral in the tri-party repo market. In these cases, the dealer's role is to serve as an intermediary between cash investors in tri-party repo (e.g., money market mutual funds and securities lenders) and a dealer's prime-brokerage clients (e.g., hedge funds).

To compare haircuts in the tri-party and the bilateral repo markets, we first need to match asset classes for the collateral used in both markets as best we can. Table 4 provides the descriptions of the collateral classes we were able to match with some degree of confidence, from high to low quality collateral. While the match is not perfect, the collateral classes are roughly similar.²⁴ The haircut data for the bilateral market are associated with repos of overnight maturity. While we do not know the maturity of repos in our tri-party repo data, numerous market participants stated that the overwhelming majority of tri-party repos were overnight during our sample period.²⁵

²⁴Note that in the case of corporate bonds, we only capture investment (IG) grade bonds for the bilateral market, while this category includes both IG and non-IG bonds for the tri-party repo market, so the haircut spread between the two markets is likely to be understated for that category.

²⁵Furthermore, the daily unwind, explained in section 2.2.3, undercuts the usual idea of maturity in the tri-party repo market. If a securities dealer defaults during the day, when all repos have been unwound, a cash investor in a term repo might choose to not send cash to the securities dealer in return for collateral, even if it were supposed

We graphically present the differences in median haircuts between the two repo markets, or haircut spread, in figure 1. A positive spread of 10 indicates that the haircut is lower in the tri-party repo market by 10 percentage points compared to the bilateral repo market (e.g., haircuts of 105 versus 115). As detailed in the figure, the spread between the median haircuts in the bilateral and the tri-party repo market increases with lower-quality collateral. The median haircut is higher in the bilateral repo market for all collateral classes except Treasuries. After the Lehman Brothers' bankruptcy, these haircut spreads increased, reaching more than 40 percentage points for subprime collateral. In general, the haircut spreads increased during the fall of 2008, peaked sometime in the first half of 2009, and were close to their July 2008 level at the beginning of 2010.

The different behavior of haircuts in the bilateral and the tri-party repo markets is a puzzle. These two markets are similar, with both using the same contractual form and the same types of collateral. The purpose of some transactions in both markets are similar—market participants have stated that financial entities use both markets for funding purposes. These two markets are also tightly linked; the larger securities dealers operate in both markets, and often provide intermediation services by re-hypothecating collateral received via bilateral repos into the tri-party repo market. All these conditions suggest that haircut behavior across these two markets should be similar. We discuss what we believe is driving the different behavior of haircuts across these two markets in section 4.

3.2 Daily changes in the collateral posted in tri-party repo

We turn to the value of collateral posted in the tri-party market and focus on how much investors and dealers change the amount they lend and borrow on a daily basis. This is one way to measure the stability of the relationship between investors and dealers.

To measure the persistence of the dealer-investor relationship, we would ideally want data on the amount dealers borrow from investors by collateral type. Because we do not have these

to do so.

data, we examine the dynamics of the relationship between dealers and investors from three perspectives. We start by looking at dealers and the day-to-day percent change in the collateral they post. We then look at investors and the day-to-day percent change in the collateral they accept. Finally, for one clearing bank we know the total amount of cash an investor loaned to a dealer over time. We use these data to measure the persistence of the amount an investor will loan a dealer.²⁶

We find that the amount of collateral a dealer posts in the triparty repo market is extraordinarily stable from day-to-day. To illustrate this point, we estimate an AR(1) process. Let $c_{d,j,t}$ denote the dollar value of collateral type j a dealer d posts at time t in the triparty repo market. We estimate

$$c_{d,j,t} = \alpha_0 + \alpha_1 c_{d,j,t-1} + \varepsilon_{d,j,t}, \quad (1)$$

where ε is an error term. We find that α_1 is equal to 0.995 with a standard error of 0.001, indicating substantial persistence in the value a dealer posts in this market by type of collateral.²⁷ Another way to measure this persistence is to compute the percentiles of the distribution of the daily percent change in collateral. For each dealer, we compute the daily percent change in value by collateral type. The median of this distribution is equal to 0; it is not until you look at the extremes of the distribution, the 10th and 90th percentiles, that we see substantial percentage changes in the value of collateral posted (see table 5).

The above analysis demonstrates that dealers essentially post the same portfolio of general collateral in triparty repo from one day to the next. Hence there is substantial stability on the dealer side of the market. Nevertheless, these statistics do not directly address the investor's side of the market. In particular, do investors persistently show up from day-to-day, or is there significant daily variation in the set of investors willing to lend in the triparty repo market?

²⁶For this quantity analysis, we dropped the six quarter end dates in our sample. Rather than being meaningful economic phenomenon, the seasonal variation at quarter-end is likely due to window-dressing efforts by financial institutions that report quarter-end results.

²⁷The standard errors are clustered by dealer.

Table 5: Distribution of the daily change in the value of collateral posted by dealers

Type of Dealer	Percentiles				
	10th	25th	50th	75th	90th
Small	-0.128	-0.031	0.000	0.044	0.126
Large	-0.095	-0.035	0.001	0.040	0.010

Note: Quarter end dates and all observations on Lehman Brothers are excluded from this analysis.

Table 6: Distribution of the daily change in the value of collateral received by investors

Investor Size (quartiles)	Percentiles				
	10th	25th	50th	75th	90th
1	-0.13	-0.01	0	0.05	0.35
2	-0.13	-0.01	0	0.03	0.23
3	-0.09	-0.01	0	0.03	0.14
4	-0.05	-0.02	0	0.02	0.05

Note: Quarter end dates are excluded from this analysis. Investors are categorized into quartiles based on the total amount of collateral they received over the sample period. Quartiles are numbered from low to high.

Once again, we estimate an AR(1) process, where the variable of interest is the total dollar value of collateral received by an investor at time t in the triparty repo market. The coefficient of interest is estimated to be 0.997 with a standard deviation of 0.001, indicating a high level of persistence similar to what we found for dealers.²⁸ Hence, the same set of investors are showing up each day and they are consistently accepting similar total amounts of collateral. For each investor, we compute the daily percentage change in the value of collateral received, and report the percentiles of this distribution. Because there is substantial heterogeneity among investors, we report these percentiles conditional on the size of the investor (see table 6). We divide into investors in quartiles, based on the total collateral received in triparty repo over our sample period.

For all four groups of investors the median percent change in collateral received is equal to 0. Furthermore, the 25th and 75th percentile of this distribution are never above 5 percent

²⁸The standard errors are clustered by investor.

and, in most cases, substantially smaller. As we saw with dealers, it is only at the extremes of the distribution, the 10th and 90th percentiles, that we see larger changes in collateral accepted from one day to the next. Even then, for the largest group of investors the 10th and 90th percentiles of the distribution are only -5 and 5 percent, respectively.

Overall, the investor and dealer statistics presented above strongly suggest that investors and dealers form persistent relationships where dealers fund a consistent amount of collateral with an investor. Further evidence of this behavior is found by examining the total amount of cash an investor lends to a dealer, using data from one of the clearing banks. Estimating an AR(1) process of the cash loaned to a dealer by an investor, results in an estimated coefficient of 0.987 on the autoregressive term, with a standard error of 0.004.²⁹

3.3 A study of 5 stress events

Up to this point, we have looked at haircuts and collateral posted independently. In this section, we focus on 5 stress dates for specific dealers, including the Lehman Brothers' bankruptcy, and look at the changes in both haircuts and collateral posted. To reinforce these findings from individual events, we end this section with a regression analysis measuring the correlations between haircuts and credit-default swap (CDS) spreads and, separately, collateral posted and CDS spreads.

In addition to the Lehman Brothers' bankruptcy, we identify four other dates of adverse shocks to individual dealers (or to their bank holding-company affiliates). We classify event dates into two categories: receipt of government assistance and negative earnings announcements. We limit our focus to three weeks before and after the event date and consider what happens to haircuts and collateral volumes in the market. Our approach is to compare the stressed dealer against its peers. To analyze haircuts, we compute the value-weighted mean haircut for the stressed dealer against the value-weighted mean haircut for a set of other large

²⁹The standard errors are clustered by investor-dealer pair.

dealers.³⁰ The difference, or spread, between these two average haircuts measures how much the haircuts faced by the stressed dealer differ from those of comparable dealers in the tri-party repo market. For collateral posted, we first calculate the daily percentage change in collateral posted by each large dealer. We then compare the change in collateral posted for the stressed dealer to the mean and standard deviation of the change in collateral posted for the set of comparable dealers.

We start by looking at the dynamics in haircuts and collateral posted for Lehman Brothers around the date of its bankruptcy. In figure 5 we plot the spread in average haircuts between Lehman Brothers relative to all other large dealers, where in the figure $t = 0$ denotes the day of the event (or the first business day following the event, if it occurred on a weekend). Surprisingly, the haircuts faced by Lehman Brothers barely moved until the event date. The Friday before Lehman declared bankruptcy, the average haircut Lehman faced was a little more than one percentage point greater than those faced by other large dealers. Most of the change in haircuts in the last days before the bankruptcy is explained by a change in composition of Lehman's tri-party repo book toward lower-quality collateral. Postbankruptcy haircuts are harder to interpret because Lehman Brothers was using the Federal Reserve's Primary Dealer Credit Facility to fund itself and posting only small amounts of collateral.

The collapse in the amount of collateral posted by Lehman Brothers is illustrated in figure 6. Significantly, the collapse in collateral was not at all gradual, but rather concentrated in the week before the firm declared bankruptcy. The Valukas Report cites sources describing much of the decline in collateral posted in tri-party repo as part of a self-imposed trend, although there were additional declines that may have been unplanned (Valukas 2010). We can think of five reasons for the decrease in collateral posted by Lehman Brothers in the tri-party repo market. First, investors in this market may have pulled back funding to protect themselves against the increased risk of a Lehman Brothers' default. The Valukas Report notes that Fidelity, a large tri-party repo investor, "requested back" its overnight tri-party repo

³⁰If event windows overlapped with one another, the dealers involved in these events were excluded from the set of comparable dealers.

Figure 5: Haircut Spread; Lehman Brothers

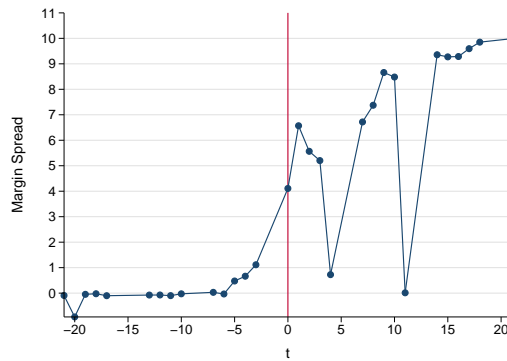
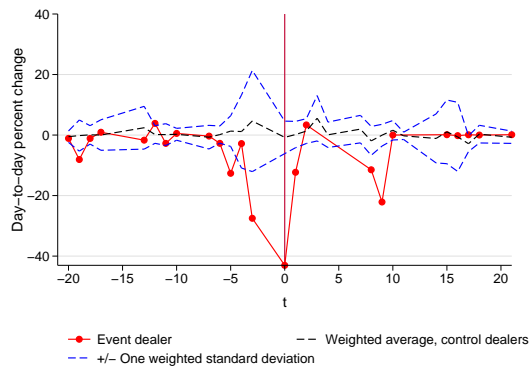


Figure 6: Percentage Change in Quantities; Lehman Brothers



Note: Seven observations after 9/15/2008 with large percent changes were dropped for stylistic reasons. These large changes were mainly driven by the small value of Lehman's book during this period.

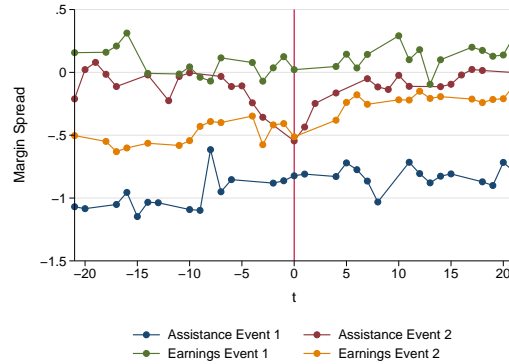
deals on September 12 (Valukas 2010). Hence, Lehman Brothers may have been forced to finance its securities in other markets (e.g. the GCF repo market described in section 2) or not at all. Second, Lehman Brothers was forced to post additional collateral with counterparties over this time, which may have reduced its tri-party repo portfolio. Third, in reaction to rumors of Lehman Brothers' upcoming demise, hedge funds and other Lehman Brothers' clients were moving their business to other broker-dealers, and thus withdrawing their collateral from Lehman Brothers. As described in Duffie (2010), losing clients has an impact on a dealer's balance sheet. In particular, Lehman Brothers would have had a smaller portfolio of securities to post as collateral in tri-party repo. Fourth, the wind down or deleveraging of the short-dated (primarily overnight) matched books in Treasuries, agency debt, and agency MBS likely played a part in the decline of tri-party funding over the course of the last few days before the actual bankruptcy. A similar deleveraging in other asset classes may also have played a role, albeit to a lesser extent. Fifth, and finally, in facing a run by investors, Lehman Brothers may have been selling collateral to raise money.

We now examine what happened to other dealers that suffered adverse shocks. In figure 7, we once again plot the difference between the weighted-average haircut faced by the stressed dealer and the weighted-average haircut faced by other comparable large dealers. Mirroring what we saw with Lehman Brothers, haircuts of stressed dealers hardly moved during these periods of stress. Indeed, somewhat surprisingly, in the case of Assistance Event 1, the stressed dealer paid consistently less than the control group throughout the event window.³¹

Turning to collateral, in figures 8 through 11 we plot the percentage change in collateral posted for the stressed dealers. Similarly to figure 6, as a point of comparison we plot the mean and standard deviation of the percentage change in collateral posted by other large dealers. As illustrated across these four figures, the four stressed dealers were able to maintain stable funding, in line with the experiences of the other large dealers. Daily percentage changes in the amount of cash borrowed by stressed dealers are generally within one standard deviation

³¹Our results are robust to different control groups and are not driven by the exclusion of overlapping event dates.

Figure 7: Haircut Spread: Adverse Events



Note: An assistance event is an event in which a dealer received government assistance. An earnings event is an event in which a dealer announced large negative earnings. The event date is denoted by $t = 0$.

of the mean percentage change for the set of comparable dealers, even around the event date. Although there is some variation from day to day, no sharp declines occur in the week before or after the event date. These findings suggest that quantities were relatively stable for these four stressed dealers, in contrast to what we observed for Lehman Brothers.³²

Overall, the above findings suggest the tri-party repo market remained stable through the crisis. Dealers that were hit with adverse shocks could continue to fund themselves by the same amount and without significant changes to haircuts.³³ Lehman Brothers is the significant exception. Tellingly, investors did not gradually alter their repo arrangements with Lehman. Rather, investors simply withdrew funding at a rapid pace.

We reinforce these findings with regression analysis using information on dealers' CDS.³⁴

³²Bolstering this result, we were able to examine the number of investors in one of the stressed dealers around its event date and found that the number of investors remained roughly constant during the days leading up to and following the stress event.

³³Because we do not have data on interest rates, we do not know whether stressed dealers were forced to pay higher rates relative to non-stressed dealers.

³⁴We obtained daily CDS spread data from Markit, a financial information services firm. To get CDS data on the largest set of dealers over our sample period, we use spreads of 5 year Modified Restructuring U.S. dollar denominated CDS contracts. This is one of the more liquid CDS contracts traded and, as a result, CDS spreads data were available on a daily basis for 14 of the largest dealers in the tri-party repo market over our sample period of July 1, 2008, to January 27, 2010.

Figure 8: Percentage Change in Quantities: Assistance Event 1

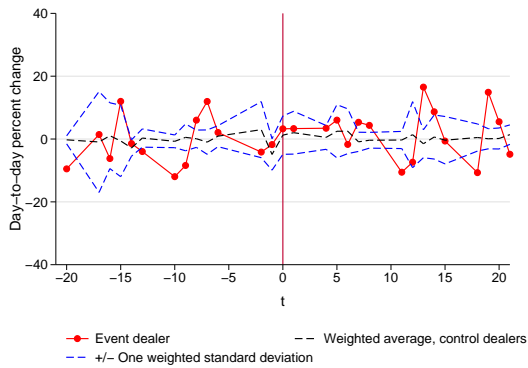


Figure 9: Percentage Change in Quantities: Assistance Event 2

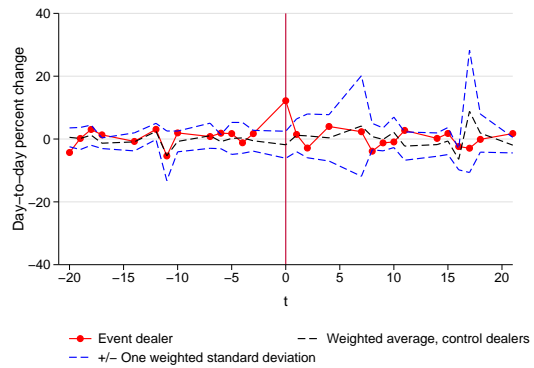


Figure 10: Percentage Change in Quantities: Earnings Event 1

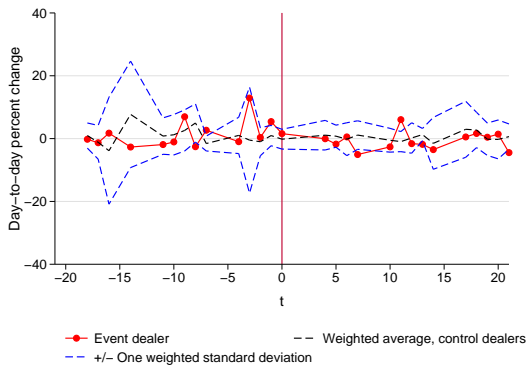
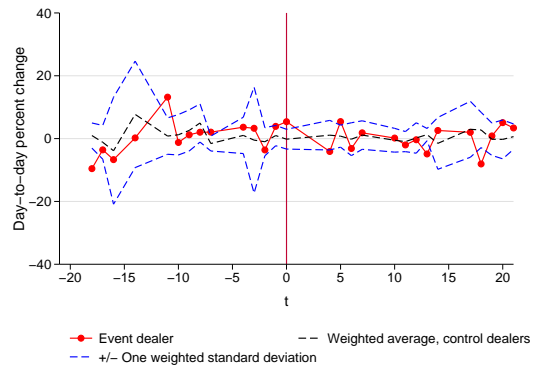


Figure 11: Percentage Change in Quantities: Earnings Event 2



Note: An assistance event is an event for which a dealer received government assistance. An earnings event is an event in which a dealer announced large negative earnings. The event date is denoted by $t = 0$.

Specifically, we regress both haircuts and value of collateral posted by dealers on their CDS spreads, with dealer, collateral type, and time fixed effects. Let $h_{d,j,t}$ denote the log of the average haircut for dealer d on collateral j at time t , and denote the log of the credit-default spread on a dealer d at time t as $r_{d,t}$. Formally, we estimate

$$h_{d,j,t} = \alpha_0 + \alpha_1 r_{d,t} + \alpha_2 r_{d,t}^2 + \sum_{k=1}^K I_{k=d} \eta_k + \sum_{k=1}^J I_{k=j} \gamma_k + \sum_{k=1}^T I_{k=t} \zeta_k + \varepsilon_{d,j,t}, \quad (2)$$

where ε is an error term, $I_{x=y}$ is an indicator variable equal to 1 when $x = y$, and the three summations denote fixed effects for dealers, collateral type, and time, respectively. A similar regression is run replacing the left-hand side variable with the log of the dollar value of collateral received.

We turn first to the regression on haircuts. To allow for the possibility that CDS spreads may have different effects on high and low quality collateral, we estimate two regressions: one which only includes Fed-eligible collateral and another which only includes the set of non Fed-eligible. For non Fed-eligible collateral, the estimated coefficients on the log of the CDS spread and the log of the CDS squared are statistically insignificant. For the Fed-eligible collateral regression, these coefficients are statistically significant, but are economically insignificant (see the upper half of table 7). The estimated coefficients imply that a one percent change in a dealer's CDS is correlated with a 0.003 percent change in haircuts, a negligible amount. In our sample, the largest change in CDS spreads is 15%. Even in this extreme case, the change in CDS spread is correlated with change in haircuts of less than 5 one-hundredths of a percent. Hence, while the counterparty can play a role in the level of haircuts (captured by the dealer fixed effects), changes in counterparty risk, as measured by movements in the CDS spread, have little explanatory power on haircuts in the tri-party repo market for any collateral class.³⁵

Turning next to the regression of collateral values on CDSs, we find the estimated coefficients on the log of the CDS spread and the log of the CDS squared are statistically insignificant

³⁵To maintain a balanced panel, Lehman Brothers was not included in the CDS regression analysis. Adding this dealer into the analysis had only negligible effects on the estimated coefficients.

Table 7: Estimated Coefficients of CDS Regressions

	Fed-eligible collateral		Non Fed-eligible collateral	
	estimate	std err	estimate	std err
<i>Independent variable: Haircuts</i>				
CDS spread	0.003	0.001	0.012	0.007
CDS spread squared	4.7e-5	1.5e-5	2.3e-4	1.3e-4
R-squared	0.36		0.49	
<i>Independent variable: Collateral Value</i>				
CDS spread	0.051	0.145	-0.170	0.147
CDS spread squared	0.001	0.003	-0.003	0.003
R-squared	0.81		0.52	

Note: std err is standard error, which are clustered by dealer. Both left-hand side variables, haircuts and collateral value, and the CDS spread are in log terms. The Fed-eligible regressions had 18,158 observations and the non Fed-eligible regressions had 20,286.

(see the lower half of table 7). Similar to our regression results on haircuts, then, the change in counterparty risk has little-to-no explanatory power on the change in Fed-eligible or non Fed-eligible collateral posted in the tri-party repo market.

Overall, the CDS regression results reinforce the findings from the event analysis presented earlier. Despite shocks to dealers in the tri-party repo market, investors do not react to the adverse information by changing haircuts, requesting better collateral, or ratcheting down the amount of they lend to dealers. The exception to this finding is, of course, Lehman Brothers. The precipitous fall in the amount of collateral Lehman Brothers posted in tri-party repo, coupled with the regression results above, suggests that adjustments in funding may be highly non-linear.

4 Discussion

In this section, we briefly consider three questions. Why did haircuts in the bilateral repo market increase so much? Why did haircuts in the tri-party repo market increase so little? How can we characterize runs in different segments of the repo market?

4.1 Why did haircuts in the bilateral repo market increase so much?

The fact that haircuts increased in the bilateral market is not particularly puzzling. Increases in haircuts is one way secured lenders can protect themselves from the risk of default of their counterparty. According to Gorton and Metrick (2011), haircuts in the bilateral repo market increased when the securities being repoed became “informationally-sensitive.” Increasing haircuts reduces the information sensitivity of the security from the perspective of the cash provider, as it reduces the likelihood that selling the securities will not cover the face value of the repo. This explanation is consistent with the fact that haircuts in the bilateral market increased more for lower quality securities, as shown in figure 1.

Having data from other segments of the repo market allows us to evaluate different hypotheses regarding the reason for the increase in haircuts. First, the increase in haircuts could reflect an increase in riskiness of the dealers’ counterparties, notably hedge funds and other dealers, during the crisis. Hence, the increase in haircut during the crisis would simply reflect the increased risk taken by dealers when providing cash to their clients or to other dealers through repos. While this possibility could explain the increase in haircut in the bilateral repo market we consider, it does not explain why haircuts increased so much in the interdealer market, which Gorton and Metrick consider, compared to the tri-party repo market. Indeed, in both markets, dealers are the borrowers.

Second, it is possible that dealers offering prime brokerage services enjoyed “monopoly rents” at the height of the crisis. According to industry analysts, before the fall of Bear Stearns many hedge funds had only one prime broker. The fall of Bear made these institutions realize the risk of such a situation, and many tried to diversify their source of prime brokerage services. However, establishing such relationships can take time and, because of the rush of new demands for services, some prime brokers turned down requests. In this environment, and at the height of the crisis, it is possible that some dealers were able to negotiate very favorable terms from their prime brokerage clients when lending cash. This explanation, however, may not explain why haircuts increased in the interdealer market studied in Gorton and Metrick

(2011).

The bilateral repo market we consider and the one Gorton and Metrick study have one thing in common. In both cases, dealers are the cash lenders. Dealers are particularly adept at financing and liquidating collateral. Thus, they are more likely to be willing to continue to lend to a counterparty while taking a higher haircut to protect themselves from the risk of default. This is not the case for some of the tri-party repo market cash investors, as we detail in the next section.

4.2 Why did the haircuts in the tri-party repo market increase so little?

Some cash investors appear to be reluctant or unprepared to take possession of the collateral and prefer to withdraw funding if they think a dealer is not creditworthy, as noted in section 3.1. The level of haircuts and the type of collateral may be unimportant for such investors, and they may not manage either carefully. For example, SEC rules prevent money market mutual funds from holding outright some of the securities they accept as collateral.³⁶

In addition, major categories of tri-party repo investors, such as money market mutual funds and commingled securities lending cash reinvestment pools, have to worry that they may face withdrawal pressures from their own investors. As a result, money funds are very intolerant of liquidity and credit risk. Upon learning that a money fund in which they have invested is financing a dealer perceived to be having creditworthiness issues or was financing a dealer now in default, investors may preemptively withdraw their funds, regardless of the risk that liquidating the collateral actually represents. This “headline” risk, the risk that a money fund may find itself in the headline of a news story, is another reason why money funds may not use haircuts to manage their risk.

Another potential explanation is that tri-party repos were mainly overnight and the clearing bank would unwind repos every morning. Hence, the cash investors were exposed to the

³⁶For example, a money market mutual fund may not be able to hold a 20-year Treasury bond, as the remaining maturity of money market mutual fund’s assets must not exceed 13 months.

dealers only overnight, from approximately 6 p.m. to 8 a.m. the next day. Cash investors may have felt that they could always pull away from a troubled dealer before it would have to declare bankruptcy, making the management of haircuts less important.

4.3 How can we characterize “runs” in different segments of the repo market?

The behavior of haircuts in the bilateral repo market can be associated with a marketwide run, or at least a generalized run on some asset classes, as suggested by Gorton and Metrick (2011). In contrast, the tri-party repo market exhibited precipitous reductions in the tri-party repo funding of specific institutions, something more similar to traditional bank runs. In particular, investors did not appear to adjust either the quantity repoed or the haircut in a gradual way.

Cash investors are able to run on a specific dealer because much of the cash in the tri-party repo market is invested overnight. This feature of the market is partly driven by the need of cash investors to respond to their own investors’ redemptions. Our data show that while large investors provide a stable amount of funding to the market, this amount occasionally fluctuates sharply, consistent with the need to meet a large redemption. During normal times, these potential needs for cash “withdrawals” are most likely not correlated and so the aggregate supply of funds to dealers remains stable. During a crisis, however, there is the potential for all cash investors to withdraw their funding from one dealer at the same time, something that resembles a traditional bank run. This behavior is similar to the motivation for banking provided by Diamond and Dybvig (1983), who focused on retail bank deposits.

Of course, given the collateralized nature of repos, cash investors can respond to changes in the perceived riskiness of a dealer by changing the applicable haircut. But as this paper documents, cash investors do not seem to use haircuts as a margin of adjustment when negotiating tri-party repos. Consequently, changes to dealer funding are driven mainly by changes in quantities of cash made available. Another margin of adjustment could be to gradually reduce funding to a dealer that is perceived to be troubled. We see no evidence of such gradual adjust-

ment. During the crisis, most dealers were able to maintain a very stable amount of funding, even during relatively stressful times. The one key exception, of course, is Lehman Brothers, whose tri-party repo book decreased sharply in the days leading up to its bankruptcy.

5 Conclusion

The U.S. tri-party repo is an important financial market, serving as a key source of funding for securities dealers, providing secondary market liquidity for Treasuries and other securities, and playing a role in pricing and price discovery of cash and derivatives instruments. As far as we are aware, this paper is the first detailed description of this market in the literature. Further, this paper provides an empirical investigation of the tri-party repo market during the crisis, focusing on the behavior of haircuts and value of collateral posted. Our main findings are that during the crisis haircuts barely moved in the tri-party repo market and that funding was very stable for dealers, with one dramatic exception. The behavior of haircuts contrasts sharply with that in the bilateral market studied by Gorton and Metrick (2011), in which haircuts increased significantly during the crisis. The differences in behavior across bilateral and tri-party repo markets during times of stress is puzzling. While we conjecture what might be driving these differences, fully understanding the behavior of securities dealers and investors in repo markets remains an important research topic.

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