Tri-Party Repo Pricing

Grace Xing Hu, Jun Pan, and Jiang Wang*

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Abstract

We document the central role of collateral in the pricing of tri-party repos. Markets are competitive for repos with safe collateral, but are severely segmented for repos with risky collateral such as equities and low-grade corporate bonds. Fund families are the sole contributors of the segmentation, and collateral concentration is the main determinant in the substantial variation in repo pricing, both across and within segments. The segmented structure points to Fidelity as a systemically important player and the markets potential fragility. Facing market segmentation, dealers optimize financing cost by allocating their collateral across fund families.

*Hu (gracexhu@hku.hk) is from University of Hong Kong, Pan (junpan@mit.edu) and Wang (wangj@mit.edu) are from MIT Sloan School of Management, CAFR, and NBER. We have benefited from comments from and discussions with Darrell Duffie, Haoxiang Zhu, Dmitry Orlov, Fan Yu, and seminar participants at the WFA 2015 and CICF 2015 meetings. We thank Bo Meng, Ai He, Xiang Yun and Yue Hu for excellent research assistance. Financial support from a Hong Kong RGC Research Grant (Project #17501014) and CAFR is gratefully acknowledged.

1 Introduction

Repurchase agreements (repos) are considered to be the largest and the most important short-term financing channel for a variety of financial institutions.[1] For these institutions, the loss of access to the repo market could be devastating. Moreover, there exists a strong spillover effect due to the highly interconnected nature of the repo market with other markets. As we saw in the recent financial crisis, disruptions in the repo market could impose a great risk to the broad financial sector, adversely affecting not only repo market participants but also other investors of similar assets. Despite its systemic importance, the repo market remains opaque to most market participants, including the regulators. Because no official data on repos exists, questions as basic as the overall size of the market are difficult to answer, let alone finding information on the market structure, activity, and pricing. Lack of data is also the main reason why empirical work lags behind theoretical discussions in this area.[2]

In this paper, we examine the trading and pricing in the tri-party repo market, based on the transaction data extracted from the recently available N-MFP reports filed by U.S. money market funds (MMFs). MMFs are important cash lenders in the tri-party repo market, accounting for around one third of the total lending. Moreover, unlike other cash lenders, MMFs are vulnerable to risk of runs by their own investors in distressed market conditions.[3] This runnable feature of MMFs make our sample represent an interesting, and potentially more important, part of the tri-party repo market. Compared with other existing repo data, our data also has the unique advantage that the information is at the transaction-level and contains details of the underlying collateral, including descriptions of issuer names, types of securities, coupons and maturity dates. Using these descriptions, we hand match the collateral to the relevant databases, security by security, and construct a large sample of tri-party repos, covering several important asset classes such as Treasuries, equities and corporate bonds.

[1]Because repo deals are transacted over-the-counter, the exact size of the aggregate repo volume is unknown. Several papers, including Gorton and Metrick (2010), Gorton and Metrick (2012) and FRBNY (2010), estimate the total amount outstanding to be approximately $10 trillion in the U.S. prior to the 2008 financial crisis.

[2]The theoretical discussions include Brunnermeier and Pedersen (2009), He and Xiong (2012), Martin, Skeie, and Thadden (2014), Gorton and Ordoez (2014), Zhang (2014), Lee (2015), among others.

[3]Other lenders in the tri-party repo market are cash rich investors include sovereign wealth funds, corporation treasures, state and local governments. More details of the tri-party repo market are discussed in Copeland, Duffie, Martin, and McLaughlin (2012).

The main economic insights and implications that arise from our study can be summarized as follows. First, we document the central role played by repo collaterals in the pricing of tri-party repos. While markets are competitive for repos with safe collateral, they are severely segmented for repos with risky collateral such as equities and low-grade corporate bonds. Our finding indicates that for risky repos, collateral risk, reflected mainly in concentration, is a key determinant of the market structure, trading, and pricing patterns. These observations are especially interesting given that the tri-party repo market is a general collateral market where any securities within an asset class can be used as collateral. It shows, despite the fact that repo investors do not favor certain securities in particular, the overall risk of the collateral is still a key factor in the repo market. We are the first to empirically study the role of collateral in the general collateral repo market, filling an important gap of the literature that often focus on special repos, where only specific securities can be used as collateral.[4]

Second, our paper is the first to document the unique and dominant role of fund families in the tri-party repo market. We find that fund families (lenders), through different collateral requirements, is the sole contributor of the market segmentation in the risky repo market. Dealer banks (borrowers), on the other hand, behave rationally to minimize their cost of financing by allocating their collateral efficiently across segments. In our analysis to disentangle different roles of fund families and dealer banks, a key element is the underlying collateral. Using our unique collateral data, we show that fund families self-select themselves into different market segments characterized by different collateral risk, and, in turn, charge different levels of haircuts and spreads. This segmented market structure highlights the importance of controlling collateral risk, beyond simple asset class labels, when investigating potential determinants of repo prices. Our empirical findings also provide challenges to the existing theoretical repo models, including Gorton and Ordoez (2014), Zhang (2014), Lee (2015), among others.

We now turn to the details of our results. For repos backed by safe collateral such as Treasuries and high grade corporate bonds, the market is competitive and the pricing, including haircut and spread, is uniform within each asset class, as commonly believed. However, for repos backed by risky collateral such as equities and low grade corporate bonds, the market is severely segmented and the pricing exhibits substantial variation, both across

[4]For example, Duffie (1996), Krishnamurthy (2002), Vayanos and Weill (2008), and Bartolini, Hilton, Sundaresan, and Tonetti (2010), among others, study why special repos enjoy different rates compared with repos with general collateral. A recent paper Wu, Liu, and Chiu (2017) finds that collateral risk is important determinant of repo pricing for tri-party repos backed by mortgage backed securities.

and within market segments, depending on the risk of collateral. Moreover, for repos with risky collateral, transactions are concentrated in the high risk segment, dominated by a single fund family. Such a structure of the market can make it more prone to systemic risks.

From the transactions data, we first observe that it is the fund families (lenders), not the dealer banks (borrowers), who shape the segmentation and trading in the risky repo market. Next, we show that different market segments are characterized by the risk level of the underlying collateral, reflected mainly on their concentration. The high risk segment is populated by fund families that are willing to accept highly-concentrated collateral, while the low risk segment is populated by fund families that require well-diversified pool of securities. The difference in the collateral concentration is substantial – while the median number of collateral per repo for the high risk fund families is only two securities, the number of collateral per repo for the low risk fund families could be close to 50 securities.

Across the two segments, repo pricing is positively correlated with the collateral concentration. Fund families in the high risk segment ask for both higher haircuts (as overcollateralization) and higher spreads (as compensation). The higher haircuts and spreads are in alignment with these fund families' collateral risk, which are naturally higher due to less diversification. In a formal regression framework which controls other repo characteristics such as counter-party, size, and maturity, all of our measures on collateral concentration show up as significant determinants of repo pricing and can explain a substantial amount of the cross section variations. The strong relationship between collateral concentration and repo pricing is also economically important. For example, an equity repo backed by ten more securities in the collateral pool will on average have 0.73 percentage point lower haircut and 1.97 basis points lower repo spreads.

Within segments, haircuts are determined by the collateral concentration and counter-party; spreads are determined by the maturity and counter-party. In terms of collateral concentration, we find that it only affects the haircut decisions of fund families in the low risk segment. That is, low risk fund families not only have more conservative concentration requirements, they also penalize repos backed by relatively more concentrated collateral with higher haircuts. In contrast, high risk fund families' haircut decisions are not sensitive to the collateral concentration. We also don't find evidences that collateral concentration affects fund families' spreads decisions.

Both across and within segments, MMFs' pricing decisions are closely linked to the concentration level of the underlying collateral. By comparison, none of the other collateral

variables, such as firm size, stock volatility, percentage of financial firms, and etc, is significant determinant of repo haircuts and spreads. It's worth pointing out that these two observations are both consistent with the fact that tri-party repos are general collateral repos. MMFs are indifferent between individual securities, but they are very sensitive to the overall risk of the securities in the collateral pool, and depend primarily on concentration to price and control their collateral risk. Our results underscore the importance of collateral in the tri-party repo market, even though these repos are designed to be general collateral trades where securities within the same asset class are substitutable for each other.

The haircuts and spreads are also sensitive to the counter-party. Fund families that trade with a large number of dealer banks vary their repo prices with respect to different counter-parties. Other fund families choose to trade with only one or two dealer banks, which can be viewed as a special case of counter-party dependence, where these fund families make a simple yes or no decision with respect to counter-parties. It is worth pointing out that fund families' preferences are not always in alignment with their counter-parties' credit risk. For example, Fidelity charges one percentage point higher haircuts and seven basis points higher spreads for their repos with JP Morgan, relative to those with Credit Suisse. However, during our sample period, JP Morgan actually has lower credit risk than Credit Suisse, as measured by their five-year CDS spreads. In fact, we only find a few individual cases where fund families' spreads decisions are in alignment with their counter-parties' credit risk.[5]

Facing a highly segmented market where fund families set their own collateral requirements and repo prices, we find dealers behave rationally to reduce their cost of financing by allocating their collateral across different fund families. Dealers tend to bundle securities that have small dollar amount together and borrow from low risk fund families that can offer low haircuts and spreads. On the other hand, to finance securities that are large in dollar amount, dealers tend to borrow from high risk fund families, since it is difficult to make these securities eligible for repo transactions with the alternative low risk fund families that require well-diversified collateral. These observations are consistent with the mechanism of

[5]For example, Charles Schwab charges significantly higher repo spreads (approximately 21 bps) for repos with Goldman Sachs relative to repos with Deutsche Bank. This is consistent with the observation that Goldman Sachs, as a dealer, have higher credit risk than Deutsche Bank during our sample period. Moreover, Charles Schwab funds also increase the repo spreads for their repos with Goldman Sachs during the months when Goldman Sachs' CDS spreads spiked up substantially, suggesting the default risk of Goldman Sachs is an important factor in Charles Schwab's repo rate decisions. In our sample of equity repos, two fund families' repo spread decisions (Charles Schwab, Goldman Sachs) are in alignment with the counter-parties' credit risk. However, we do not find such a situation in fund families' haircut decisions.

the collateral allocation process in the tri-party repo market, where dealers allocate their collateral efficiently to their lenders manually or with the assistance of linear programming software.[6]

Take JP Morgan as an example, the dealer holds, on average, approximately seven stocks with dollar value above one hundred million and sixty stocks with dollar value below one million, at each month-end during our sample period. For stocks with dollar value above one hundred million, 83% of the total amount are allocated as collateral for transactions with Fidelity funds (in the high risk segment) and only 16% are allocated as collateral for transactions with Morgan Stanley funds (in the low risk segment). By comparison, for the stocks with dollar value below one million, the ratios change to 38% for Fidelity and 60% for Morgan Stanley. Other dealers behave similarly and allocate their collateral efficiently across fund families in different market segments.

While the above results on trading and pricing are most evident for equity repos, for which we have a large sample of repo transactions with matched collateral information, they also hold for high-yield corporate bond repos, though with few observations due to the noise in the matching process.[7] In particular, the cross-sectional variation in repo haircuts sand spreads can be largely explained by the collateral concentration, and are not related to other collateral characteristics such as bond ratings and maturities.

In addition, we find that for equity and high-yield corporate bond repos, most of the transactions occur in the high risk segment. Moreover, the high risk segment of both markets is dominated by one fund family, Fidelity. Such a market structure makes Fidelity a systemically important player in these markets. The high segmentation in these markets further exacerbates this situation and increases the fragility of the market in terms of systemic risk.

In sharp contrast to the risky repo market, the Treasury repo market is highly competitive and the pricing is uniform. There are no dominate players in terms of transaction volume. Fund families show no differences in the collateral that they accept, usually consisting only a few Treasury securities, and in many cases, just one single Treasury security. This could be due to the fact that combining multiple Treasury securities together doesn't achieve the same

[6]The collateral allocation process in the tri-party repo market is discussed in details in Copeland, Duffie, Martin, and McLaughlin (2012).

[7]The pricing of repos backed by safer investment-grade corporate bonds are very homogeneous, similar to the Treasury repo market, as we discuss later.

level of diversification as in equities or low grade corporate bonds, since Treasury securities are strongly positively correlated with each other. But even with one single Treasury security, the haircut levels in the Treasury repo market, proportional to the collateral risk, are actually higher than those in the risky repo market. For Treasury repos, the uniform haircut is set to be two percents and the return volatility of the underlying collateral typically range from four to five percents per year. This implies that the Treasury repo haircuts are set at the levels around 40% to 50% of the annualized collateral volatility. By comparison, the same ratio for equity repos is below 30%. In other words, per one unit of collateral' return volatility, the haircut of Treasury repos is actually higher than the haircut of a typical equity repo.[8] Such a difference may well reflect the different nature of risks for the collateral, Treasuries versus equities.

Overall, we find that collateral plays a central role in the repo market, in determining its market structure, trading, and pricing patterns, especially for repos with risky collateral. In particular, for these risky repos, the market is highly segmented by the risk level of collateral as measured by their concentration. Most of the cross-sectional variations in the repo pricing are direct results of the severe market segmentation. In addition, we show that transactions are highly concentrated in the high risk segment, which is also dominated by a single fund family. Such a market structure raises questions about the systemic robustness of the markets of risky repos.

The collateral details in our repo data make it possible for us to quantify the risk of the securities in the collateral pool and thereby examine how repo trading and pricing are linked to collateral. We are also able to control the collateral risk when investigating the relations between repo prices and other potential factors, such as counter-party credit risk. This is essential for the study of repos because results would be inconclusive and potentially misleading if the collateral risk are left uncontrolled.

To our best knowledge, this level of granular collateral information has never been collected and studied before. There are only two existing dataset on tri-party repos that we are aware of.[9] The one most related to ours is discussed in Krishnamurthy, Nagel, and Orlov

[8]The high risk fund families in the equity repo market charge haircuts in the range from 8% to 9% for collateral with annualized return volatility around 30%, while the low risk fund families charge haircuts around 5% for collateral with annualized return volatility around 20%.

[9]In Gorton and Metrick (2010) and Gorton and Metrick (2012), the authors use a private repo data provided by an anonymous dealer. However, the data covers only bilateral repos in the interbank market. Fecht, Nyborg, Rocholl, and Woschitz (2016) studies repos between German banks and the central bank. Kyung Auh and Landoni (2016) uses a proprietary bilateral repo data provided by a hedge fund. These

(2014), which is based on the top 20 money market fund families' quarterly filings (N-CSR, N-CSRS and N-Q) before the 2010 MMF reform. Since money market funds disclose only the general asset classes in quarterly filings, their repo data does not have the collateral information at the security level. The focus on only the top 20 fund families also raises the question of how representative these repo transactions are. By contrast, our data covers the repo transactions by all U.S. money market funds, totaling 751 individual funds from 160 fund families. Another set of tri-party repo data is collected by the Federal Reserve Bank of New York, as discussed in Copeland, Martin, and Walker (2014). Their data contains daily aggregate quantity numbers across lender-dealer pairs for various collateral asset classes. Due to the aggregation, transaction-level repo information is lost. Hence the authors focus on the average haircuts faced by each dealer in each collateral asset class.

With our unique deal-level data with collateral information, we complement Krishnamurthy, Nagel, and Orlov (2014) by focusing on the cross-sectional variations of the prices of risky repos; and add to Copeland, Martin, and Walker (2014) by identifying that the main determinant of repo pricing is the fund family. The demands made by different fund families, not by dealers, cause the wide variations in haircuts and spreads. Both papers document interesting facts during the crisis period, but our results help shed light on how the repo market works under normal market conditions in the post crisis period.[10]

Lastly, our work is also related to the literature on money market funds. This strand of literature includes McCabe (2010), Kacperczyk and Schnabl (2013), Chernenko and Sunderam (2014), Strahan and Tanyeri (2015), among others. Our focus is on money market funds' tri-party repos, which represent an important component of their investment portfolios.

The rest of paper is organized as follows. Section 2 describes how we collect the repo data and match the individual securities. Section 3 investigates the determinants of haircuts and spreads for repos backed by equities. Section 4 studies the Treasury repos, and Section 5 studies the corporate bond repos. Section 6 concludes the paper.

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dataset are different from the tri-party repos that we discuss in this paper.

[10]It is worth noting that our data, extracted from monthly filings, only contains money market funds' repo positions at the end of each month. One might concern about potential month-end window dressing activities by MMFs and dealer banks. Results in Copeland, Martin, and Walker (2014) have shown that the daily repo funding volume and pricing do not change substantially around month-end reporting days, even during the very volatile financial crisis period. We therefore think it is unlikely that the pricing of tri-party repos could change drastic within months during our sample, which falls into the post-crisis period with much calmer market conditions.

2 Data

2.1 The repo market

A repurchase agreement is a spot sale of securities coupled with a forward agreement to buy back the same securities in the future with interest. In its simplest form, a repurchase agreement is very much like a short-term collateralized loan between two counter-parties, a lender who originally buys the securities and a borrower who uses its securities for a secured cash loan. There are two major types of repos used in the market: bilateral repos and tri-party repos.

In a bilateral repo, the collateral and cash are exchanged directly between two counter-parties at both the onset and the maturity of the repo transaction. Tri-party repos use a third-party bank, which acts as both the custodian and the clearing agent for the two counter-parties in a repo deal. The third-party bank, either JP Morgan Chase or Bank of New York Mellon in the U.S., handles all the administrations of the repo transaction, including receiving and delivering securities and cash, marking securities to market and etc. The clearing service provided by the third-party bank helps minimize the operational burden of the lenders, especially those who don't have personnel or technologies to handle complicated collateral posted by the borrowers. The third-party bank also acts as the intra-day financier for the cash borrower during the time gap associated with the unwinding of repos. Copeland, Duffie, Martin, and McLaughlin (2012) provides a detailed discussion of the role of the clearing banks in tri-party repo transactions.

Besides differences in the settlement arrangement, these two forms of repos also have very different clienteles. Bilateral repos are commonly used by dealers to provide funding for their hedge fund clients, or among dealers to redistribute cash and certain securities. In a tri-party repo market, dealers are usually cash borrowers and lenders are cash-rich investors such as money market funds, security lenders, and sovereign funds. Most importantly, unlike bilateral repos whose transaction details are seldom disclosed to the public, recently available filings of money market funds provide a unique opportunity for us to study the tri-party repo market empirically.[11]

[11]The vast majority of the repos by MMFs are tri-party. During recent period, MMFs start to do more bilateral repos in response to several reforms of the money market fund industry and the tri-party repo market. For our sample period, which is from November 2010 to August 2013, we believe that bilateral repos done by MMFs are very uncommon. We therefore follow the practice of Krishnamurthy, Nagel, and Orlov (2014) and treat all of the observations in our sample as tri-party repos.

2.2 The MMF tri-party repo data

In the US tri-party repo market, money market funds (MMFs) are important players, representing approximately one third of the market share. Our main data source comes from monthly portfolio holdings of money market funds after November 2010. Following the Securities and Exchange Commission's money market fund reforms in 2010, money market funds in the U.S. are required to file their detailed portfolio information, at individual security level, with the SEC through N-MFP forms. The N-MFP forms reflect money market funds' portfolio holdings on the last business day of each month and must be filed before the fifth business day in the following month. The SEC then makes the monthly N-MFP data publicly accessible after a 60-day delay.

We download all N-MFP forms available on the SEC's EDGAR website for the period from November 2010 to August 2013, and then parse these text files to extract information for each item on these forms.[12] Our main interest is money market funds' repurchase agreement holdings. Compared with other reports filed by money market funds before the 2010 reforms, the new N-MFP forms require money market funds to report not only basic information about their repurchase agreements such as the counter-party dealer, maturity, amount, haircut and interest rate, but also all the security details underlying each repurchase agreement. For each underlying security, money market funds need to report the security type, name of the issuer, maturity date, coupon or yield, principal amount and collateral value. However, to avoid extremely lengthy filings, the SEC does allow a fund to simply select the range for the number of the securities from one of the four categories: 51-100, 101-500, 501-1000, or more than 1000, instead of listing all the collateral security by security.[13] Some money market funds adopt this practice, but we do observe many cases in our data where money market funds routinely report the full list of collateral even when the number of the underlying securities exceeds 50.

Although money market funds describe the underlying securities in the N-MFP forms, the descriptions required by the SEC don't include security identifiers such as CUSIP or ISIN codes. Thus the biggest challenge in our data processing procedure is to identify these

[12]Our data covers 751 money market funds in the U.S., sponsored by 160 unique fund families. Among all the money market funds, there are 310 prime funds, 131 government/agency funds, 80 Treasury funds, 121 single state funds and 109 tax-exempt funds.

[13]For more information on the SEC's regulation of the N-MFP filings, readers can check the SEC's website http://www.sec.gov/divisions/investment/guidance/formn-mfpqa.htm.

securities through the text descriptions provided by money market funds. We focus on matching securities in three asset classes (equities, corporate bonds and Treasuries) because only these securities have standard and publicly accessible databases on their issuance and historical prices. We discuss the details of our matching methods in the Internet Appendix.

2.3 Data summary

Table 1 summarizes the repo characteristics for the three classes of tri-party repos that we constructed. Clearly, the pricing of tri-party repos, including both haircuts and spreads, varies substantially across different collateral asset classes. Repos backed by equity securities have the highest haircut, with an average of 7.36% and a median of 8.01%; repos backed by Treasury securities have the lowest haircut, with an average of 2.02% and a median of 2.00%. Among the corporate bond repos, the haircuts of high-yield corporate bond repos are similar to those of the equity repos, while the haircuts of investment-grade corporate bond repos are around 5.00%, lower than the haircuts of equity and high-yield corporate bond repos, but higher than the haircuts of Treasury repos.

Repo spreads exhibit similar pattern across different collateral asset classes: equity and high-yield corporate bond repos have the highest spreads, approximately 40 bps above the overnight Fed Fund Rates; followed by investment-grade corporate bond repos (approximately 20 bps) and then Treasury repos (approximately 1-2 bps). The pattern of the haircuts and spreads are consistent with the existing literature that the pricing of tri-party repos are strongly associated with the asset classes of the underlying collateral.

More importantly, Table 1 also shows that tri-party repos backed by risky asset classes are not priced uniformly. The standard deviation of the equity repos' haircuts is 1.95% and the standard deviation of the high-yield corporate bond repos' haircuts is 1.86%. The wide cross-sectional dispersions in haircuts for these two asset classes can also be seen from Figure 1, which plots the median, the lowest 25% (Q1) and the highest 25% (Q3) haircuts month by month from November 2010 to August 2013. For the equity repos, although the median haircut stays stably at around 8% throughout our sample, the lowest 25% percentile of haircuts often reaches 5% and the highest 25% percentile of haircuts often reaches 9%. The observation is similar for high-yield corporate bond repos. By comparison, the cross-sectional dispersions are much smaller for investment-grade corporate bond repos and Treasury repos. Both the lowest 25% and the highest 25% percentile of the haircuts stay at 5% for investment-grade corporate bond repos and 2% for Treasury repos throughout our sample period. In

other words, there exists rich variations in the haircuts of repos backed by risky assets, while only repos backed by safe assets have relative uniform haircuts. Our paper therefore focus on understanding the pricing of tri-party repos backed by equity and high-yield corporate bonds.

We also find that money market funds ask for more diversified pools of collateral for repos backed by risky asset classes. The median number of collateral per repo is only one security for Treasury repos. By comparison, the median number of collateral per repo is ten for equity repos and three for high-yield and investment-grade corporate bond repos. Other measures of collateral concentration, such as the value-weighted number of collateral per repo and the maximum collateral weight per repo, show similar patterns.

In terms of other repo characteristics, equity and corporate bond repos usually have longer maturities and smaller sizes. The median maturity is seven days for equity repos, seven days for high-yield corporate bond repos, and six days for investment-grade corporate repos. On the other hand, majority of the Treasury repos are overnight. Moreover, Treasury repos are substantially larger than repos backed by other asset classes. The median size of Treasury repos is 90 million, around three to four times larger than the median size of the equity repos and the corporate bond repos.

Lastly, there are significantly less number of money market funds and dealers that participate in the repo market backed by risky asset classes, relative to those backed by safe asset classes. There are seven fund families that lend in the equity repo market, only a fraction of the fund families, 81 in total, that lend in the Treasury repo market. Similarly, the number of dealers that borrows with risky asset classes is also much lower that those that borrows with Treasury securities.

3 Equity Repos

In this section, we study the market structure and the pricing of equity repos. We first show that it is the fund families, not the dealer banks, who shape the segmentation in the equity repo market. In particular, some families are willing to accept collateral backed by only a few securities (high risk segment), while other fund families require collateral to be backed by well-diversified securities (low risk segment). Next, we show that fund families in the high risk segment demands both higher haircuts and higher spreads, resulting a strong positive relationship between repo prices and collateral concentration across the two segments. We

then discuss how individual fund families set haircuts and spreads, which characterizes how repo prices vary within segments. Lastly, we discuss how dealers behave when they face such a highly segmented repo market.

3.1 Market segmentation

The equity repo market is severely segmented, and both haircuts and spreads exhibit substantial variations. Table 2 reports the summary statistics of the 3,296 equity repos during the 34-month period from November 2010 to August 2013. There are in total seven fund families and fifteen dealers in our sample of equity tri-party repos. Panel A summarizes the repo characteristics separately for each of the seven fund families (lenders); Panel B summarizes the repo characteristics separately for the top five dealers (borrowers). Both fund families and dealers are ranked by their corresponding market shares in the equity repo market.

Transactions in the equity repo market are highly concentrated in a few large fund families and dealers. On the lenders' side, Fidelity alone has 2,118 equity repos with a total amount of 173,850 million in our sample period, accounting for over 60% of the total market in both numbers and size. The second largest lender is Morgan Stanley fund family, having in total 254 equity repos with a total amount of 42,643 million. Morgan Stanley fund family accounts for around 8% of the market in terms of numbers and 15% of the market in terms of size. The other five fund families, in the order of their market shares, are: Charles Schwab, Bank of America, Federated Investors, Goldman Sachs and State Street.

On the borrowers' side, JP Morgan (JPM), which is the largest dealers, has in total 1,114 repos with a total amount of 116,654 million in our sample. Credit Suisse (CS), which is the second largest dealers, has in total 731 repos with a total amount of 85,340 million. The other three dealers in the top five list are Deutsche Bank (DB), Goldman Sachs (GS), and Mizuho group (MFG). The top five dealers, in total, account for approximately 85% of the market in terms of numbers and 90% of the market in terms of size, suggesting that the remaining ten dealers are not major players in the equity repo market. Clearly, the tradings in the equity repo market are disproportionately concentrated in a few large fund families and dealer banks.

Regarding the trading relationship, we find that large fund families often lend to multiple dealers while small fund families trade with much fewer counter-parties. Table 3 reports the total amount and the total number of equity repos for each pair of fund families and dealers

that trade at least once in our sample. Fidelity, which is the largest fund family by market share, lends to twelve out of the total fifteen dealers. Morgan Stanley, the second largest fund family by market share, lends to ten out of the fifteen dealers. The remaining five fund families have much fewer number of counter-parties. Charles Schwab funds lends only to Deutsche Bank (DB) and Goldman Sachs (GS); Bank of America funds lends to J.P.Morgan Chase (JPM), Credit Suisse (CS), Deutsche Bank (DB), ABN AMRO (AMA), Barclays (BCS) and ING Group (ING); Federated Investors funds lend only to Credit Suisse (CS); Goldman Sachs funds lend only to ABN AMRO (AMA) and Societe Generale (GLE); and State Street funds lend only to Credit Suisse (CS). From the angle of dealers, large dealers tend to borrow from multiple fund families while smaller dealers rely mainly on the the two largest fund families, namely Fidelity and Morgan Stanley funds, to finance their equity repos.

In terms of pricing, the most important observation is that it is the fund families, not the dealer banks, who determine the prices in the equity repo market. As shown in Table 2, most of the variations in the haircuts comes from differences across different fund families. Fidelity funds ask for haircuts above 8%; State Street and Goldman Sachs funds ask for haircuts around 8%; Bank of America ask for haircuts around 7%, Morgan Stanley and Charles Schwab funds ask for 5%; Federated Investors funds ask for only 2%. By comparison, haircuts charged by money market funds within the same family have much smaller variations. For the largest lender, i.e., Fidelity money market funds, the standard deviation of haircuts is only 0.86% and the inter-quartile range is 0.82%. Both numbers are substantially smaller than those for the full sample of equity repos. For the rest fund families, five of them have inter-quartile ranges of haircuts less than 0.1%. The only fund family that has a wide variation in its haircuts is Bank of America, with the standard deviation at 2.19% and the inter-quartile range at 3.01%.

On the other hand, haircuts faced by a dealer are often much more dispersed, especially when the dealer borrows from multiple fund families. For example, the inter-quartile range in haircuts is 2.96% for Credit Suisse and 3.00% for Deutsche Bank. These large dispersions are the results of the substantially different levels of haircuts charged by funds from different families. In our sample, Credit Suisse borrows from five fund families; Deutsche Bank borrows from four fund families. Not surprisingly, the dispersions in haircuts are much smaller for dealers that borrow mainly from one fund family, for example, JP Morgan, Goldman Sachs, and Mizuho. Take JP Morgan as an example, the inter-quartile range of

haircuts is only 0.18%. This is because majority of its equity repo deals are with funds from Fidelity (#1,027) and only a tiny fraction of deals (#87) are with funds from Morgan Stanley and Bank of America. Therefore, the small variation in haircuts is largely due to the fact that JP Morgan borrows most from Fidelity, and Fidelity assigns similar haircuts for its repos with JP Morgan.

3.2 Collateral concentration and repo pricing

The pricing of repos are strongly positively related to the concentration of the underlying collateral. This strong relationship is the direct result of the self-selection by fund families into different market segments, characterized by their requirements on collateral concentration. Fund families in the high risk segment are willing to accept more concentrated collateral while fund families in the low risk segment demand well-diversified collateral. To hedge and compensate for their higher collateral risk, fund families in the high risk segment demand both higher haircuts and higher spreads. The variations in repo prices are therefore largely determined by the concentration of the underlying collateral across the two segments.

Table 4 reports the cross-sectional mean, median and standard deviations of the collateral characteristics for each fund family, in the descending order of their collateral concentration. We use three different measures to measure a repo's collateral concentration: the equal-weighted number of securities in the collateral pool, the value-weighted number of securities in the collateral pool, and the maximum weight of the securities in the collateral pool.[14] In addition, we also report several other collateral characteristics, firm size, volatilities, and the percentage of financial firms, as control variables. The firm size is calculated as the value-weighted average of individual collateral's total book assets. We calculate two volatility measures for a repo's collateral: the volatility of a value-weighted portfolio consisting of all securities in the collateral pool and the value-weighted average of the individual securities' volatilities. The volatilities are estimated using the daily returns during a one-year window prior to the repo date. To proxy for potential wrong-way risk, we also report the value-weighted proportions of financial firms in the collateral pool. For all these calculations, the weights are the collateral value of each security divided by the total collateral value of all

[14]The weight of a security in the collateral pool is calculated the collateral value of the security divided by the total collateral value of all securities in the collateral pool. To calculate the value-weighted number of securities in the collateral pool, we first calculate the Herfindahl index as $H = \sum_{i=1}^{N} w_i^2$, where w_i is the weight of the security i and N is the total number of securities in the collateral pool. We then calculate the value-weighted number of securities in the collateral pool as the inverse of the Herfindahl index H.

securities in the collateral pool.

Fidelity is the dominant high risk fund family that are willing to accept collateral consisting a few number of securities. The median number of collateral is only two for Fidelity's equity repos. After taking into account the differences in the collateral values, the median value-weighted number of collateral securities per repo of Fidelity drops further to 1.58. For half of Fidelity's repos, more than 77% of the collateral value is concentrated is one single security. By comparison, Morgan Stanley is a dominant low risk fund family that requires substantially more securities for their equity repos. For Morgan Stanley funds' repos, the median number of securities per repo is 47.00, the median value-weighted number of securities per repo is 37.46, and the median maximum weight of securities per repo is only 3%. For the remaining five fund families, their concentration requirement are in the middle between Fidelity funds' and Morgan Stanley funds' requirements.

Due to the diversification effect, the high risk fund families' repos also have higher collateral volatility than those by the low risk fund families. For example, the average portfolio volatility of Fidelity funds' equity repos is 29.45%, nine percentage points higher than those of Morgan Stanley funds' equity repos. Moreover, the securities in the Fidelity funds' collateral pools have similar individual volatilities as those in the Morgan Stanley funds' collateral pools - the average individual volatility is 34.08% for the securities accepted by Fidelity funds and 33.22% for the securities accepted by Morgan Stanley funds. Therefore, the reason why Fidelity funds' equity repos have higher collateral volatility is because Fidelity funds are willing to accept collateral pools that are more concentrated in a few securities. We don't observe significant differences in other aspects of the collateral, such as firm size and the percentage of financial firms, suggesting that fund families' collateral requirement differ mainly on their concentration requirements.

More importantly, we observe a strong positive relationship between fund families' collateral concentration requirements and their repo prices. Figure 2 plots fund families' haircuts against their collateral concentration levels. For each fund family, the blue vertical line represents the range from the lower-quartile (Q1) to the upper-quartile (Q3) of the haircuts; the blue horizontal line represents the range from the lower-quartile to the upper-quartile of the collateral concentration, measured as the maximum weight of securities in a collateral pool; the horizontal line and the vertical line intersects at the median of haircuts and collateral concentration. In addition, we also plot a red filled circle centered at the median of the haircuts and collateral concentration for each of the fund families, where the size of the

circle is proportional to the market share of the fund families.

As shown in Figure 2, the equity repo market shows two separate segments, one with high collateral concentration (high risk) and one with low collateral concentration (low risk). Fund families in the high risk segment tend to ask for substantially higher haircuts than low risk fund families. This segment is dominated by Fidelity, which accepts collateral with maximum weight ranging from 0.40 (Q1) to 1.00 (Q3) and charges haircuts spreading from 8.01% (Q1) to 8.83% (Q3). By comparison, Morgan Stanley, as the largest low risk fund family, requires collateral with maximum weight below 0.10, and charges substantially lower haircuts at around 5.00%. For the remaining fund families, most of their collateral concentration levels and haircuts are between those set by the Fidelity funds (highest risk) and the Morgan Stanley funds (lowest risk). For the purpose of illustration, we don't include two fund families, Federated Investors and State Street, in the plot, because they trade only with one dealer (Credit Suisse) for a very short time period during our sample. We think this is likely due to some special arrangements between the fund families and the dealer.

We formally investigate the relationship between repo pricing and collateral characteristics in a regression framework. The results are reported in Table 5. The left panel of Table 5 shows that all of our measures of collateral concentration are statistically significant determiants of repo haircuts. The equity repo haircuts will increase 0.13% when the equal weighted number of collateral per repo decreases by 10. Similarly, the equity repo haircuts will increase by 0.73% when the value weighted number of collateral per repo decreases by 10; the equity repo haircuts will increase by 2.81% as the maximum collateral weight per repo moves from 0.0 to 1.0. The haircuts of repos with the maximum collateral weight per repo in the range of $(5\%, 10\%]$ are 1.61% higher than those with the maximum weight below 5%; the haircuts of repos with the maximum collateral weight per repo in the range of $(10\%, 100\%]$ are 2.50% higher than those with the maximum weight below 5%.

In the above regressions, we control several additional collateral characteristics such as the value-weighted firm size (log), the portfolio volatility, and the percentage of financial firms. We also control other potential effect on haircuts driven by differences in the size of the repo (repo value) and the tenors of the repos (dummy variable for term repo and the repo maturity in calendar days). We use dealer dummies and the dealers' five-year CDS spreads to control potential dealer effect, and use month dummies to control for potential time effect. We don't include dummies for fund families in these regressions because the cross-sectional variations in the collateral concentration and repo haircuts are mostly variations across fund

families.

Consistent with the fact that tri-party repos are general collateral trades, concentration is the only collateral variable that can robustly explain the variations in haircuts. Controlling for collateral concentration, repo haircuts are not sensitive to the firm size, portfolio volatility, and the percentage of financial firms in the collateral pool. In other words, fund families use simple concentration measures to control the collateral risk and do not take into account other characteristics of the securities in the collateral pool. Repo haircuts also do not show significant relations to dealers' credit spreads and other repo characteristics such as size and tenors.

We then investigate the determinants of repo spreads using a similar regression setting. We measure the repo spreads as the repo yields in excess of the overnight fed fund rate on the repo date. The results are reported at the right panel of Table 5. Similar to the observation on repo haircuts, repos backed my more concentrated collateral also have higher spreads. The equity repo spreads will increase 0.44 bps when the equal weighted number of collateral per repo decreases by 10; the equity repo spreads will increase by 1.97 bps when the value weighted number of collateral per repo decreases by 10; the equity repo spreads will increase by 9.49 bps as the max weight of collateral moves from 0.0 to 1.0; the haircuts for repos with the maximum weight in the range of $(5\%, 10\%]$ are 6.77 bps higher than repos with the maximum weight below 5%; the haircuts for repos with the maximum weight in the range of $(10\%, 100\%]$ are 8.66 bps higher than repos with the maximum weight below 5%. In addition to collateral concentration, the repo maturity is also a significant determinants of the repo spreads. Term repos on average have 9 bps to 10 bps higher spreads than overnight repos, and one extra calendar day in the repo maturity will increase the repo spreads by around 0.12 bps. All other control variables are not statistically significant.

3.3 Fund families' pricing schemes

In this section, we further investigate how fund families, in each segment, set their repo prices. Haircuts are mainly determined by the collateral concentration and counter-party. Moreover, collateral concentration only affects the haircut decisions of fund families in the low risk segment. That is, low risk fund families not only have more conservative concentration requirements, they also penalize repos backed by relatively more concentrated collateral with extra higher haircuts. Repo spreads, on the other hand, are not sensitive to collateral concentration and are mainly determined by the maturity and counter-party.

For each fund family, we regress the haircuts and spreads on collateral characteristics, dummies for dealers, dealers' CDS spreads, repo size, dummy for term repo, and repo maturity.[15] The collateral characteristics variables include the collateral concentration measure (col max weight), and other control variables such as the average firm size of the collateral (col size),the return volatility of the collateral as a portfolio (col volatility), and the percentage of financial firms in the collateral pool (col financial). We measure the spreads of a repo as the repo yield minus the overnight Fed Fund Rate on the repo transaction date.

Table 6 reports the regression results on haircuts, and Table 7 reports the regression results on repo spreads.[16] The omitted dealer dummy is the dummy for Credit Suisse for the regression results of Fidelity, Bank of America and Morgan Stanley; the omitted dealer dummy is the dummy for Deutsche Bank (DB) for the regression results of Charlse Schwab; the omitted dealer dummy is the dummy for ABN AMRO Bank (AMA) for the regression results of Goldman Sachs. To save space, we only report the regression coefficients on several major dealer dummies: JP Morgan (JPM), Deutsche Bank (DB), Barclays (BCS), ABN AMRO Bank (AMA), Goldman Sachs (GS), and Societe General (GLE).

Repo haircuts

The dominant fund family in the high risk segment, Fidelity, assigns haircuts mainly according to the counter-party identities. Relative to their repos with Credit Suisse, Fidelity funds charge 0.99% higher haircuts for repos with JP Morgan, 0.76% higher haircuts for repos with Deutsche Bank, 0.31% higher haircuts for repos with Barclays, and 0.73% higher haircuts for repos with Societe General. At the same time, none of the collateral characteristics variables is statistically significant, suggesting that Fidelity doesn't consider collateral when they assign haircuts.

By comparison, the haircut schemes of the fund families in the low risk segment are all sensitive to the collateral concentration and the counter-party. For all four fund families, Bank of America, Goldman Sachs, Charles Schwab, and Morgan Stanley, the coefficients for

[15]We don't perform regression tests for two fund families, Federated Investors and State Street, because they charge constant haircuts and trade only with Credit Suisse for a very short time period during our sample.

[16]In Table 6 and Table 7, we report the regression results where the collateral concentration measure is the maximum weight of the securities in the collateral pool. We also constructed two other collateral concentration measures: the equal-weighted number of securities in the collateral pool and the value-weighted number of securities in the collateral pool. The results remain similar.

the collateral concentration measure are positive and statistically significant at the 5% level. The coefficients are also large economically. As the maximum weight of collateral per repo moves from the minimum level (0.04) to the maximum level (0.97) of Bank of America's equity repos, haircuts will increase 3.51%, fifty percent larger than one standard deviation of 2.19%. Similarly, the coefficients imply an increase in haircuts of 0.87% for Goldman Sachs, 0.05% for Charles Schwab, and 1.50% for Morgan Stanley, as the maximum collateral weights per repo increases from the minimum level to the maximum level in the respective fund family.

Out of all of the collateral characteristics variables, only the collateral concentration measure shows up as the variable which can consistently explain the haircuts for all of the four fund families whose haircut schemes depend on the collateral. The coefficients for the firm size of the underlying collateral are not statistically significant for all of the four fund families. We also don't find evidence that they consider potential wrong-way risk, as proxied by the percentage of financial firms in the collateral, in their haircut decisions. Due to less diversification, the collateral with more concentrated securities will naturally have higher return volatilities. However, when we combine the collateral concentration measure with the portfolio volatility measure together, the coefficients on volatility are insignificant for three out of the four fund families, with the only exception being Bank of America. In other words, fund families, as unsophisticated investors in the tri-party repo market, rely mainly on simple concentration measures to assess and control their collateral risk.

Similar to Fidelity, the haircut decisions of fund families in the low risk segment are also sensitive to the counter-party. Bank of America and Morgan Stanley are the two low-risk fund families that trade with many dealers. Relative to their repos with Credit Suisse, Bank of America funds give 3.52% higher haircut for their repos with Deutsche Bank and 4.23% higher haircut for their repos with ABN AMRO Bank; Morgan Stanley funds give 0.17% higher haircut for their repos with Deutsche Bank and 0.40% higher haircut for their repos with Barclays. For Goldman Sachs and Charles Schwab, though we don't observe significant difference in their haircuts with different dealers, these two fund families trade only with two dealer banks. This can be viewed as a special case of counter-party dependence, where these fund families make a simple yes or no decision with respect to counter-parties.[17]

Although all fund families' haircut decisions are counter-party sensitive, it's worth noting

[17]Two other similar cases are Federated Investors and State Street. These two fund families assign constant haircuts, but they only trade one counter-party which is Credit Suisse.

that credit risk can not explain fund families' preference over certain dealers. For example, Fidelity funds charge close to one percentage point higher haircuts for repos with JP Morgan relative to repos with Credit Suisse. However, the five-year CDS spread of JP Morgan are always lower than those of Credit Suisse during our sample period. Similarly, Morgan Stanley charges similar haircuts for repos with Credit Suisse and Societe General, but Societe General's five-year CDS spreads are around two times larger than Credit Suisse's five-year CDS spreads. In addition, controlling the dummy variables for the dealers, dealers' five-year CDS spreads are not significant determinant of haircuts for all of the fund families. In short, though fund families use counter-party sensitive haircut schemes, their preferential treatment of certain dealers can not be explained by the credit risk of the dealers.

Repo Spreads

Repo spreads are mainly determined by the maturity and counter-party. As shown in Table 7, term repos and repos with longer maturity tend to have higher spreads. The maturity effect is as expected and reflects the upward term structure during our sample period. Interestingly, for funds in both the high risk and the low risk segments, spreads are not sensitive to collateral concentration. In other words, although low risk fund families penalize repos backed by relative more concentrated collateral with higher haircuts, they do not penalize these repos with higher spreads. Repo spreads are also not sensitive to other collateral variables, such as firm size, volatilities, and the proportion of financial firms.

Fund families' spreads decisions are counter-party specific. For some fund families, their spreads decisions are consistent with the dealers' credit risk. These fund families include Charles Schwab and Goldman Sachs. For example, Charles Schwab gives significantly higher spreads for repos with Goldman Sachs (GS) relative to repos with Deutsche bank (DB). This is consistent with the observation that Goldman Sachs, as a dealer, has higher credit risk than Deutsche Bank during our sample period. In addition, the repo spreads between Charles Schwab and Goldman Sachs follow a similar time-series trend as Goldman Sachs' CDS spreads, suggesting that Charles Schwab also charges higher spreads for their repos with Goldman Sachs during the months when Goldman Sachs' credit spreads increases. The spreads for repos between Charles Schwab and Deutsche Bank, on the other hand, remain quite stable during our sample period. Clearly, Charles Schwab funds actively manage their repo spreads with Goldman Sachs, and the credit risk of the counter-party is an important

consideration in Charles Schwab's repo rate decision. Not surprisingly, the regression results in Table 7 also show that the two coefficients on the dealer dummy (Godman Sachs) and the dealers' CDS spreads are statistically significant.

Interestingly, the preference of several other fund families can not be explained by the credit risk of the counter-parties. For example, relative to the repo spreads with Credit Suisse, Fidelity funds charges 6.83 bps higher spreads for their repos with JP Morgan, 10.86 bps lower spreads for their repos with Barclays, and 11.27 bps lower spreads for their repos with Societe General. Another example is Bank of America funds. They charge JP Morgan 6.27 bps higher spreads than Credit Suisse. However, as seen from Figure 2, JP Morgan actually has the lowest five-year CDS spreads among all dealers during our sample period.

3.4 Dealers' behavior

Facing a highly segmented market, we find dealers behave rationally to minimize their cost of financing by allocating their collateral efficiently across segments. Dealers tend to bundle securities that have small dollar amount together and borrow from low risk fund families that offer low haircuts and spreads. For the securities that are large in dollar amount, dealers tend to borrow from high risk fund families, because it is difficult to make these securities eligible for repo transactions with the low risk fund families that have more restrictive collateral concentration requirement. In other words, we find that dealers are optimizing their financing cost by allocating their collaterals with counter-parties across different segments.

Table 8 shows that collateral allocation of JP Morgan, Credit Suisse, and Deutsche Bank. These three dealers are the top three dealers in the equity repo market that can borrow from multiple fund families, including both the high risk fund families and the low risk fund families. For each dealer, we first aggregate all the collateral provided by this dealer, stocks by stocks, at each month. We then look at how the dealer allocate these securities to different repo transactions with different counter-parties.

Our first observation is that the securities provided by dealers are usually with substantially different size. Take JP Morgan as an example, they hold on average 6.8 number of stocks with value above 100 million, 66.8 number of stocks with value between 10 and 100 million, 102.2 number of stocks with value between 1 and 10 million, and 59.4 number of stocks with value below 1 million. The pattern is similar for Credit Suisse, they hold on average 3.1 number of stocks with value above 100 million, 59.2 number of stocks with value between 10 and 100 million, 114.4 number of stocks with value between 1 and 10 million,

and 141.9 number of stocks with value below 1 million. Deutsche bank also exhibit a similar pattern, but they hold less number of stocks with large dollar amount.

More interestingly, we find that all dealers share a similar pattern when they allocate their securities as collateral to different fund families. For stocks with high value, dealers tend to split the stock as collateral for multiple repos and borrow more from Fidelity which can tolerate more concentrated collateral. For stocks with low value, dealers tend to bundle the stock with other securities as the collateral for one repo, and borrow more from Morgan Stanley funds which lower charges low haircuts and spreads. Comparing the high value stocks with amount above 100 million and the low value stocks with amount below 1 million, the average number of repos backed by high value stocks is 3.7, while the average number of repos backed by low value stocks is only one. For high value stocks, 83% of their repos are with Fidelity and only 16% of their repos are with Morgan Stanley. By comparison, for the low-value stocks, only 38% of their repos are with Fidelity and 60% of their repos are with Morgan Stanley. The pattern is very similar for Credit Suisse and Deutsche Bank. Clearly, dealers are forced to borrow from Fidelity when they need to finance stocks with large value. In this case, it is impossible to borrow from the Morgan Stanley which requires a well-diversified collateral pool where individual stock values can not be too large. For stocks with small amount, dealers tend to bundle them with other small amount stocks and borrow from Morgan Stanley which offers lower haircuts and lower spreads.

4 Treasury Repos

Our main focus in this paper is the trading and pricing of repos backed by risky collateral, especially the equity repos for which we have a large sample of transactions with matched collateral information. However, it is worth emphasizing that majority of the repos between money market funds and dealer banks are indeed backed by safe government collateral, mainly Treasuries and Agency securities. To draw a parallel with the risky repo market, we investigate the Treasury repo market in this section.[18] We find that the trading in the Treasury market is very competitive, and the haircuts and spreads are priced homogeneously across different fund families, consistent with the common belief.

Unlike the very segmented equity repo market which is dominated by a few large players,

[18]We didn't investigate the the Agency repo market because there is no standard database available on the prices of the Agency securities.

the Treasury repo market involves a large number of fund families and dealers. Table 9 reports the summary statistics for the top ten fund families and the top ten dealers. On the lenders' side, there are 81 unique fund families. Federated Investors is the largest lender in the Treasury repo market, but it only accounts for approximately 12% of the total lending. This is much less than the top fund family's market share (Fidelity) in the equity and corporate bond repo markets. The total market share of the top five fund families is approximately 45%; and the total market share of the top ten fund families is 68%.

On the borrowers' side, there are in total 30 dealers. Barclays is the largest borrower, followed by Royal Bank of Scotland, Deutsche Bank, Credit Suisse and BNP Paribas. All top five dealer banks are non-US European banks. The top five dealers account for 53% of the market share; the top ten dealers account for 77% of the market share; and the rest 20 dealers account for 23% of the market share. The lenders and borrowers are also more inter-connected in the Treasury tri-party market. Compared with the equity and corporate bond repo markets, both the lenders and the borrowers also tend to trade with more counterparties in the Treasury repo market.

In terms of collateral, majority of the Treasury collateral are Treasury Notes. Table 10 summarizes the underlying Treasury securities in the collateral pool for the top ten fund families, as well as for the full sample. On average, 79% of securities are Treasury Notes, 15% are Treasury Bonds and the remaining 6% are Treasury Bills. The average age of the Treasury collateral is 2.39 years. A small fraction of the collateral, around 10.83%, are on-the-run securities.

Treasury repos are usually backed by only a few number of securities. On average, there are only approximately 3.83 number of securities, or 2.35 value-weighted number of securities, per one Treasury repo. The average maximum collateral weight per repo is 0.80, and more than half of the Treasury repos are backed by only one security. Federated Investors, the largest fund family in the Treasury repo market, requires relative more diversified pool of securities than other fund families. The differences, however, are not as big as the case in the equity repo market. We don't observe significant differences in other collateral characteristics such as age, maturity, coupons, outstanding amount, and etc.

Most importantly, we find that pricing in the Treasury repo market is quite homogeneous across fund families. As shown Table 9, most of the haircuts are uniformly set at the 2.00% level. Take Federated Investors as an example, the ninth decile (P90) of haircuts is 2.03%, very close to the first decile of 2.00%. The standard deviation of haircuts is also small, at

only 0.07%. The pattern is similar for the full sample and most of the top ten fund families.[19]

We formally test the determinants of the haircuts and spreads of Treasury repos in Table 11. Not surprisingly, none of the collateral variables is related to haircuts or spreads. The counter-party risk variable, which is measured as dealers' CDS spreads, is also insignificant. For repo spreads, month dummies and repo maturity variables alone can explain close to 60% of the total variations. Therefore, the variations in spreads are likely due to the time-series changes of the overall credit market. Consistent with the common belief, the haircuts and spreads are very homogenous for repos backed by Treasury securities.

5 Corporate bond repos

In addition to equities, corporate bonds are also a popular form of non-government collateral in the tri-party repo market. According to the statistics provided by SIFMA, the amount of corporate bonds posted as collateral in the tri-party repo market has similar magnitude as the equities, at approximately $85 billion per month from November 2010 to August 2013.

Table 12 summarizes the corporate bond repos for the top five fund families in our sample, Panel A for repos backed by high-yield corporate bonds and Panel B for repos backed by investment-grade corporate bonds. Similar to the equity repo market, Fidelity is also the largest fund family in the corporate bond repo market. The fund family, alone, accounts for 65% of the market share in the high-yield corporate bond repo market and 47% of the market share in the investment-grade corporate bond repo market.

Fidelity is also the fund family that accepts substantially more concentrated collateral than other fund families in the corporate bond repo market. For the high-yield corporate bond repos, the average of the number of collateral per repo is 7.3, the average of the value-weighted number of collateral per repo is 3.7, and the average of the maximum collateral weight per repo is 0.70. Similarly, for the investment-grade corporate bond repos, the average of the number of collateral per repo is 8.1, the average of the value-weighted number of collateral per repo is 3.9, and the average of the maximum collateral weight per repo is 0.70. Again, similar to the equity repo market, Fidelity is also the dominant fund family that are willing to take high collateral risk. Due to missing information in Fidelity's monthly reports, we don't have the detailed information, other than the collateral concentration, on Fidelity's

[19] Among the top ten fund families, the standard deviations of haircuts are higher than 0.3% for Morgan Stanley and Northern Trust fund families. This is likely due to reporting errors, and potential noises introduced in the collateral matching process.

corporate bond collateral. However, for the collateral that we are able to match, we don't find significant differences in bond maturities and ratings, across different fund families.

In terms of pricing, we find that high-yield corporate bond repos are priced similar to the equity repo. There is a very strong positive relationship between the repo haircuts and the underlying collateral' concentration levels. Panel A of Figure 3 plots the haircuts against the collateral concentration levels (measured as the maximum collateral weight) for the top five fund families in the high-yield corporate bond repo market. Fidelity, the dominant fund family that takes high risk collateral, ask for haircuts at around 8%, the highest among all fund families. Other fund families, such as Blackrock, Morgan Stanley, Bank of America and Federated Investors, have more restrictive requirements on the collateral concentration and ask for lower haircuts that range from 2% to 7%.

On the other hand, the investment-grade corporate bond repos are priced more uniformly across fund families, similar to the Treasury repo market. As shown at Panel B of Figure 3, the top three fund families, Fidelity, Bank of America, and Morgan Stanley, all price their repos at the 5% level. For the rest two fund families, Blackrock charges 7% haircuts and Barclays charges 3% haircuts. But these two fund families, combined together, only account for less than 10% of the market shares.

We formerly test the determinants of corporate bond repos' haircuts and spreads in a regression setup at Table 13. For the repos backed by high-yield corporate bonds, we find that repos backed by more concentrated collateral have higher haircuts and spreads. As the max weight of the collateral pool increase from 0 to 1, haircuts will increase by 1.17% and spreads will increase by 3.11 bps. Other collateral variables, such as ratings and maturities, are not statistically significant determinants of repo haircuts and spreads.[20] Again, similar to the pricing of equity repos, fund families in the high-yield corporate bond repo market only care about the concentration levels of the collateral and do not seem to take into account other collateral characteristics in their pricing decisions.

By comparison, none of the collateral variables are significant determinants of the haircuts and spreads of investment-grade corporate bond repos. For the collateral concentration measure, the coefficient is -0.07 with t-value of -0.84 for the regression on haircuts, 1.14 with t-value of 1.55 for the regression on spreads. The coefficients on collateral ratings

[20]The number of observations for corporate bond repos drops a lot when the collateral maturity and the collateral rating variables are included in the regressions. This is because we can't match the collateral of Fidelity funds' corporate bond repos due to missing information in these funds' N-MFP forms.

and maturities are also insignificant. Moreover, we don't find evidence that repo prices vary significantly across dealers or associated with dealers' credit risk. In other words, the investment-grade corporate bond repos are priced relatively homogeneously, similar to the Treasury repo market.

6 Conclusions

Taking advantage of a unique data set of repo transactions between U.S. money market funds and dealer banks, we examine the trading and the pricing in the tri-party repo market. For repos backed by safe collateral assets, such as Treasury and investment-grade corporate bonds, the market is competitive and the repo prices are uniform, within each asset class. However, for repos backed by risky collateral assets, such as equities and high-yield corporate bonds, the market is highly segmented and the repo prices vary substantially, both across segments and within segments. The segmentation is shaped by fund families who self-select different collateral risk, through requirements on the collateral concentration levels. Fund families in the high risk segment ask for higher haircuts and spreads, resulting a strongly positive relationship between repo prices and collateral concentration across segments. Within segments, haircuts are mainly determined by collateral concentration and counter-party; spreads are mainly determined by maturity and counter-party. Facing a highly segmented market, dealers behave rationally to minimize their cost of financing by allocating their collateral across different fund families.

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Table 1: Summary statistics of the matched sample of tri-party repos

			corporate bond		
variables		equity	high-yield	investment	Treasury
#fund families		7	9	15	81
#funds		36	39	47	290
#dealers		15	15	20	30
#repos		3,296	750	1,161	15,436
haircut (%)	mean	7.36	7.18	4.90	2.02
	median	8.01	8.00	5.01	2.00
	std	1.95	1.86	0.72	0.28
spread (bps)	mean	39.22	39.65	22.95	1.43
	median	39.00	38.00	20.00	2.00
	std	18.37	13.51	12.54	5.01
size ($million)	mean	85	126	66	185
	median	33	28	20	90
	std	144	328	124	293
maturity (days)	mean	34	11	9	3
	median	7	7	6	1
	std	42	22	15	6
number of collateral (ew)	mean	19.84	13.25	8.12	3.83
	median	10.00	3.00	3.00	1.00
	std	35.35	19.45	11.85	13.90
number of collateral (vw)	mean	11.36	6.45	3.79	2.35
	median	4.16	1.87	1.82	1.00
	std	13.71	8.51	4.91	5.28
maximum weight of collateral	mean	0.47	0.60	0.65	0.80
	median	0.37	0.64	0.68	1.00
	std	0.40	0.38	0.33	0.28

This table reports the summary statistics of our matched sample of tri-party repos from November 2010 to August 2013. Haircut is calculated as the ratio between the difference of the collateral value and the repo value, divided by the repo value. Spread is calculated as the repo yield minus the overnight Federal Fund Rate on the repo transaction date, reported in basis points. The number of collateral (ew) counts the number of securities in the collateral pool backed by each repo. The number of collateral (vw) is the inverse of the Herfindahl index, where the weights are the value of each security in the collateral pool divided by the total collateral value. The maximum weight of collateral is the value of the security that has the maximum amount among all securities in the collateral pool, divided by the total collateral value.

Table 2: Fund families and dealers in the equity tri-party repo market

Panel A: all fund families

			repo haircut (%)					repo spread (bps)					repo maturity (#days)					repo size ($m)				
fund family	#repos	amt ($m)	mean	std	Q1	med	Q3	mean	Std	Q1	med	Q3	mean	std	Q1	med	Q3	mean	std	Q1	med	Q3
Fidelity	2,118	173,850	8.48	0.86	8.01	8.70	8.83	42.3	18.8	23.0	44.0	57.0	39.3	45.2	4	19	63	82	155	5	17	83
Morgan Stanley	254	42,643	5.13	0.46	5.00	5.01	5.01	24.1	14.6	15.0	18.0	30.0	5.0	12.3	1	1	3	168	197	30	90	230
Charles Schwab	604	25,725	4.99	0.08	4.99	5.00	5.00	42.2	15.8	22.0	46.0	54.0	39.8	37.0	3	32	73	43	41	12	30	65
Bank of America	146	13,188	8.02	2.19	6.52	7.26	9.53	24.1	6.4	19.0	24.0	29.0	24.5	29.2	1	4	40	90	74	45	57	120
Federated Investors	99	12,213	2.03	0.04	2.01	2.03	2.07	28.1	3.6	26.0	28.5	30.5	7.0	0.0	7	7	7	123	105	40	100	200
Goldman Sachs	57	5,750	8.29	0.70	8.00	8.00	8.01	28.1	9.9	22.0	24.0	39.0	1.7	1.4	1	1	2	101	95	99	100	100
State Street	18	5,650	8.01	0.01	8.00	8.00	8.00	14.8	1.4	14.0	14.5	16.0	1.5	0.8	1	1	2	314	143	225	300	450

Panel B: top five dealer banks

			dealer CDS (bps)		repo haircut (%)					repo spread (bps)					repo maturity (#days)					repo size ($m)				
dealer	#repos	amt ($m)	mean	std	mean	std	Q1	med	Q3	mean	std	Q1	med	Q3	mean	std	Q1	med	Q3	mean	std	Q1	med	Q3
JPM	1,114	116,654	98	24.0	8.54	1.00	8.71	8.79	8.89	50.1	14.1	43.0	54.0	59.0	62.2	49.2	19	54	93	105	179	7	28	132
CS	731	85,340	123	31.7	6.70	2.14	5.10	8.00	8.06	33.5	21.4	16.0	27.0	43.0	19.9	25.4	2	7	32	117	158	13	54	165
DB	302	19,470	131	37.7	6.42	2.30	5.00	5.00	8.00	21.5	6.7	17.0	21.0	22.0	2.6	2.5	1	1	4	64	109	15	35	78
GS	434	18,586	201	84.7	4.99	0.07	4.96	5.00	5.00	51.1	8.2	44.0	52.0	56.0	54.5	33.6	27	52	81	43	42	9	30	65
MFG	203	10,167			8.55	1.83	8.00	8.01	8.07	26.0	6.3	22.0	25.0	31.0	5.3	2.4	3	7	7	50	124	4	9	37

This table reports the distribution of haircut, spread, maturity and size for our sample of tri-party equity repos from November 2010 to August 2013. Panel A reports the summary statistics for each of the seven fund families. Panel B reports the summary statistics for the top five dealers, ranked by the total equity repo amount. The top five dealers are JP Morgan (JPM), Credit Suisse (CS), Deutsche Bank (DB), Goldman Sachs (GS) and Mizuho Financial Group (MFG). In addition to the repo statistics, we also report the time-series mean and standard deviation of the dealers' five-year CDS spreads in Panel B. The CDS spreads data are obtained from Markit Inc. We don't report Mizuho Financial Group's CDS spreads since it is not covered by Markit.

Table 3: Trading relationship between fund families and dealer banks in the equity tri-party repo market

Panel A: total amount of equity tri-party repos ($millions)

	Fidelity	Morgan Stanley	Charles Schwab	BoA	Federated Investors	Goldman Sachs	State Street
JPM	101,174	14,848		632			
CS	42,927	16,940		7,610	12,213		5,650
DB	5,785	4,270	7,139	2,276			
GS			18,586				
MFG	9,552	615					
BAC	7,055	715					
AMA		2,890		2,354		1,600	
GLE	1,393	1,075				4,150	
BCS	3,694	840		125			
MER	1,093	430					
MTU	786						
BNP	216	20					
ING				191			
C	138						
UBS	37						

Panel B: total number of equity tri-party repos

	Fidelity	Morgan Stanley	Charles Schwab	BoA	Federated Investors	Goldman Sachs	State Street
JPM	1,027	71		16			
CS	465	70		79	99		18
DB	76	32	170	24			
GS			434				
MFG	197	6					
BAC	82	4					
AMA		24		19		28	
GLE	29	18				29	
BCS	171	23		5			
MER	19	4					
MTU	30						
BNP	2	2					
ING				3			
C	8						
UBS	12						

This table reports the total amount of repos (in millions) and the total number of repos for each pair of fund families and dealers that have traded at least once in our equity tri-party repo sample from November 2010 to August 2013. Both fund families and dealers are listed in the order of their total amount of repos during the sample period. The list of dealers are JP Morgan (JPM), Credit Suisse (CS), Deutsche Bank (DB), Goldman Sachs (GS), Mizuho Financial Group (MFG), Bank of America (BAC), ABN AMRO Bank (AMA), Societe Generale (GLE), BarclayS (BCS), Merrill Lynch (MER), Mitsubishi Financial Group(MTU), BNP Paribas Group(BNP), ING Group (ING), Citi Group (C), and UBS (UBS).

Table 4: Equity collateral characteristics by fund families

	collateral concentration			collateral volatility			
fund family	#cols (ew)	#cols (vw)	max weight	individual	portfolio	size	financials
				mean			
Fidelity	7.20	3.83	0.69	34.08	29.45	159	0.21
State Street	20.72	7.28	0.34	36.28	28.16	180	0.20
Federated Investors	39.48	13.02	0.22	29.41	20.26	84	0.23
Bank of America	39.46	14.36	0.14	32.01	19.03	119	0.19
Goldman Sachs	30.34	16.49	0.09	27.24	18.70	237	0.23
Charles Schwab	34.34	24.57	0.05	32.93	22.05	133	0.20
Morgan Stanley	71.48	39.83	0.04	33.22	20.45	100	0.17
All	20.01	11.39	0.47	33.46	26.46	147	0.20
				median			
Fidelity	2.00	1.58	0.77	32.83	27.79	21	0.00
State Street	13.50	5.78	0.29	36.66	27.88	82	0.18
Federated Investors	32.00	12.22	0.21	29.22	20.13	85	0.23
Bank of America	27.00	12.54	0.10	31.66	17.66	35	0.17
Goldman Sachs	17.00	12.97	0.09	25.39	17.15	235	0.23
Charles Schwab	22.00	21.67	0.05	32.99	22.24	106	0.19
Morgan Stanley	47.00	37.46	0.03	33.18	20.03	80	0.17
All	10.00	4.17	0.37	32.53	24.66	38	0.12
				stanard deviation			
Fidelity	10.21	6.19	0.32	11.06	11.07	412	0.33
State Street	15.03	4.76	0.21	9.71	6.23	238	0.19
Federated Investors	46.31	9.45	0.11	3.85	3.18	51	0.10
Bank of America	45.44	7.14	0.16	6.75	6.85	263	0.16
Goldman Sachs	31.95	8.83	0.01	6.39	6.02	141	0.10
Charles Schwab	42.31	9.62	0.00	6.49	5.49	118	0.09
Morgan Stanley	69.25	11.46	0.02	6.05	5.33	84	0.08
All	36.24	13.78	0.40	9.71	10.31	341	0.27

This table reports the summary statistics of the equity collateral for each of the seven fund families in the equity tri-party repo market, from November 2010 to August 2013. We first calculate, for each equity repo, the number of collateral (#cols (ew)), the value-weighted number of collateral (#cols (vw)), the value-weighted average of collateral' individual volatility (in percentages), the portfolio volatility of collateral (in percentages), the value-weighted average of collateral' firm size (total book assets in billions), and the proportion of financial firms (financials). The weights are the collateral value of individual securities divided by the total collateral value of the repo. We then report the cross-sectional mean, median and standard deviation of these collateral variables across all repos for each of the fund families.

Table 5: Collateral concentration v.s. haircuts and spreads for equity repos

parameter	haircuts					spreads				
col number (ew)		-0.013**					-0.044			
		[-2.51]					[-1.81]			
col number (vw)			-0.073***					-0.197**		
			[-7.42]					[-2.20]		
col max weight				2.808***					9.485***	
				[2.84]					[5.48]	
col max weight [5% 10%]					1.606***					6.770***
					[6.26]					[3.73]
col max weight (10%, 100%]					2.496***					8.657***
					[6.98]					[3.07]
col firm size	0.061	0.004	-0.072	-0.13	-0.058	-0.184	-0.382	-0.543	-0.831	-0.593
	[1.01]	[0.06]	[-0.86]	[-1.27]	[-0.76]	[-0.37]	[-0.68]	[-0.90]	[-1.66]	[-1.00]
col portfolio vol	0.043	0.037	0.02	0.005	0.019	0.114	0.093	0.053	-0.015	0.032
	[1.45]	[1.30]	[1.04]	[1.12]	[1.03]	[1.15]	[1.00]	[0.56]	[-0.24]	[0.36]
col financials	0.11	0.233	0.386	0.503	0.371	-2.253	-1.83	-1.512	-0.926	-1.365
	[0.39]	[0.74]	[1.09]	[1.36]	[1.07]	[-0.54]	[-0.44]	[-0.35]	[-0.23]	[-0.33]
dealers' CDS	-0.004	-0.003	-0.003	-0.004	-0.004	0.017	0.021	0.02	0.019	0.018
	[-1.44]	[-1.12]	[-1.10]	[-1.31]	[-1.18]	[0.87]	[1.16]	[1.06]	[1.10]	[0.89]
repo size	-0.012	0.065**	0.124***	0.210***	0.028	-0.733**	-0.467	-0.366	0.018	-0.608**
	[-0.39]	[2.09]	[3.17]	[4.52]	[1.20]	[-2.26]	[-1.73]	[-1.15]	[0.07]	[-2.04]
term repo	-0.021	-0.079	-0.26	-0.1	-0.377	10.293**	10.095**	9.650***	10.026**	9.059**
	[-0.04]	[-0.15]	[-0.52]	[-0.21]	[-0.71]	[2.40]	[2.47]	[2.61]	[2.41]	[2.46]
repo maturity	0.005	0.004	0.003	0.003	0.004	0.124***	0.122***	0.118***	0.119***	0.122***
	[0.94]	[0.85]	[0.69]	[0.92]	[0.86]	[3.32]	[3.33]	[3.18]	[3.38]	[3.09]
dealer dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
month dummies	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
nobs	3082	3082	3082	3082	3082	3082	3082	3082	3082	3082
adj R2	49.7	53.9	64.0	59.5	63.0	57.6	58.1	58.7	58.8	59.4

This table reports the OLS regressions results on repo haircuts and spreads for all equity tri-party repos from November 2010 to August 2013. We measure the spreads of a repo as the repo yield minus the overnight Fed Fund Rate on the repo transaction date. We use three different measures to measure a repo's collateral concentration: the equal-weighted number of securities in the collateral pool (col number (ew)), the value-weighted number of securities in the collateral pool (col number (vw)), and the maximum weight of the securities in the collateral pool (col max weight). Other control variables include average firm size of the collateral (col firm size), return volatility of the collateral as a portfolio (col portfolio vol), and the percentage of financial firms in the collateral pool (col financials), dealers five-year CDS spreads, repo size, dummy for term repo (term repo), repo maturity, dummies for dealers, and dummies for months. The t-statistics reported in squared brackets are based on the double-clustered standard errors by both months and fund families, and, ** and *** denote significance at the 5% and 1% level.

Table 6: Individual fund families' haircuts schemes

	High	By collateral concentration			Low
fund family	Fidelity	BoA	Goldman Sachs	Charles Schwab	Morgan Stanley
col max weight	-0.209	3.804***	17.074***	1.353**	14.602***
	[-1.50]	[8.79]	[2.74]	[2.27]	[3.24]
col firm size	0.019	-0.289	-0.25	0.011	-0.013
	[1.62]	[-1.38]	[-1.02]	[0.89]	[-0.41]
col portfolio vol	-0.002	0.187***	0.055	0.009	0.008
	[-0.84]	[7.14]	[1.76]	[1.34]	[1.33]
col financials	-0.024	-0.713	-1.376	0.045	-0.424
	[-0.26]	[-1.38]	[-1.43]	[0.57]	[-1.14]
JPM	0.991***	-0.423			-0.002
	[11.01]	[-1.35]			[-0.02]
DB	0.762***	3.516***			0.173***
	[5.61]	[9.80]			[2.99]
BCS	0.307***				0.400**
	[3.05]				[2.49]
AMA		4.234***			0.075
		[10.33]			[0.98]
GS				-0.032	
				[-0.56]	
GLE	0.728***		-0.426		-0.415
	[6.75]		[-1.51]		[-1.69]
dealers' CDS	-0.003	-0.014	-0.004	0.000	0.001
	[-1.15]	[-0.89]	[-1.59]	[-0.01]	[0.28]
repo size	-0.03	-0.421***	0.05	0.002	-0.024
	[-1.86]	[-2.98]	[1.54]	[0.51]	[-1.26]
term repo	0.08	-0.332***	0.603***	0.064	0.125***
	[0.67]	[-2.82]	[2.83]	[1.59]	[2.88]
repo maturity	-0.002***	0.001	0.004	-0.001	-0.003
	[-2.70]	[0.28]	[0.11]	[-1.77]	[-0.86]
month dummies	Y	Y	N	Y	Y
nobs	1898	138	52	604	238
adj R2	41.5	91.9	35.8	22.3	56.2

This table reports the OLS regressions results on repo haircuts for each of the seven fund families in the equity tri-party repo market from November 2010 to August 2013. The fund families are ordered by their collateral' concentration levels. The explanatory variables include the collateral concentration measure (col max weight), average firm size of the collateral (col firm size), return volatility of the collateral as a portfolio (col portfolio vol), and the percentage of financial firms in the collateral pool (col financials), dealers five-year CDS spreads, repo size, dummy for term repo (term repo), repo maturity, dummies for dealers, and dummies for months. To save space, we only report the regression coefficients on several major dealer dummies: JP Morgan (JPM), Deutsche Bank (DB), Barclays (BCS), ABN AMRO Bank (AMA), Goldman Sachs (GS), and Societe General (GLE). The t-statistics reported in squared brackets are based on the standard errors clustered by months, and, ** and *** denote significance at the 5% and 1% level.

Table 7: Individual fund families' spreads schemes

	High	By collateral concentration			Low
fund family	Fidelity	BoA	Golman Sachs	Charles Schwab	Morgan Stanley
col max weight	0.709	0.64	-59.865	-18.328	128.655
	[0.41]	[0.39]	[-1.10]	[-0.26]	[1.88]
col firm size	-0.001	-0.002	-0.014	0.018***	0.004
	[-0.47]	[-1.12]	[-1.09]	[3.49]	[0.28]
col portfolio vol	0.014	0.014	-0.072	-0.031	-0.361
	[0.23]	[0.15]	[-0.30]	[-0.21]	[-0.94]
col financials	-2.269	1.567	29.348	-4.822	8.1
	[-1.31]	[0.75]	[1.77]	[-0.89]	[0.90]
JPM	6.828***	6.271***			4.848
	[3.05]	[2.63]			[1.32]
DB	-4.966	1.582			3.276
	[-1.46]	[1.49]			[1.23]
BCS	-10.860***				29.456***
	[-3.36]				[5.64]
AMA		-0.649			0.42
		[-0.43]			[0.15]
GS				20.584***	
				[6.06]	
GLE	-11.274***		6.506		-6.533
	[-3.97]		[1.47]		[-0.96]
dealers' CDS	-0.032	0.110***	0.070**	0.121***	0.081
	[-0.77]	[3.16]	[2.08]	[4.27]	[0.79]
repo size	-0.449	-1.785	-0.783	-0.233	-0.803
	[-1.71]	[-1.39]	[-1.53]	[-1.42]	[-1.84]
term repo	13.005***	8.086***	-9.834	0.572	0.977
	[4.41]	[3.68]	[-1.68]	[0.25]	[0.28]
repo maturity	0.114***	0.014	1.912	0.013	0.465***
	[5.80]	[0.32]	[1.85]	[0.49]	[6.02]
month dummies	Y	Y	N	Y	Y
nobs	1898	138	52	604	236
adj R2	55.6	81.6	63.7	93.5	69.5

This table reports the OLS regressions results on repo spreads for each of the seven fund families in the equity tri-party repo market from November 2010 to August 2013. We measure the spreads of a repo as the repo yield minus the overnight Fed Fund Rate on the repo transaction date. The fund families are ordered by their collateral' concentration levels. The explanatory variables include the collateral concentration measure (col max weight), average firm size of the collateral (col firm size), return volatility of the collateral as a portfolio (col portfolio vol), and the percentage of financial firms in the collateral pool (col financials), dealers five-year CDS spreads, repo size, dummy for term repo (term repo), repo maturity, dummies for dealers, and dummies for months. To save space, we only report the regression coefficients on several major dealer dummies: JP Morgan (JPM), Deutsche Bank (DB), Barclays (BCS), ABN AMRO Bank (AMA), Goldman Sachs (GS), and Societe General (GLE). The t-statistics reported in squared brackets are based on the standard errors clustered by months, and **, and *** denote significance at the 5% and 1% level.

Table 8: Dealers' collateral allocation

	JPM				CS			
	below 1m	[1 10]	[10 100]	above 100m	below 1m	[1 10]	[10 100]	above 100m
#stocks per month	59.4	102.2	66.8	6.8	141.9	114.4	59.2	3.1
#repos per stock	1.0	1.1	1.6	3.7	1.2	1.5	2.5	4.0
average repo value	237	294	358	345	312	317	298	325
#collateral per repo (ew)	65.3	50.7	29.0	19.8	101.0	85.0	50.8	25.8
#collateral per repo (vw)	30.6	25.1	14.9	10.4	31.9	29.5	18.2	8.0
collateral weight of the stock	0.01	0.03	0.13	0.40	0.01	0.02	0.11	0.36
Fidelity	0.38	0.52	0.78	0.83	0.19	0.27	0.48	0.60
Morgan Stanley	0.60	0.46	0.21	0.16	0.54	0.51	0.24	0.04
	DB				all dealers			
	below 1m	[1 10]	[10 100]	above 100m	below 1m	[1 10]	[10 100]	above 100m
#stocks per month	60.8	46.0	13.6	0.4	473.7	331.8	162.6	13.6
#repos per stock	1.1	2.3	4.7	3.7	1.2	1.8	4.2	6.9
average repo value	301	129	184	378	179	203	246	259
#collateral per repo (ew)	315.4	95.2	68.0	12.4	172.7	74.9	47.8	29.0
#collateral per repo (vw)	44.0	30.1	25.9	6.5	42.2	30.3	20.9	13.6
collateral weight of the stock	0.01	0.04	0.09	0.45	0.01	0.03	0.10	0.29
Fidelity	0.08	0.07	0.18	0.73	0.19	0.32	0.47	0.63
Morgan Stanley	0.67	0.37	0.31	0.02	0.34	0.36	0.24	0.15

This table reports the collateral allocation for JP Morgan (JPM), Credit Suisse (CS), Deutsche Bank (DB), and all dealers. We first aggregate all the collateral provided by each of the dealer at the end of each month, stock by stock. For each of the stock, we trace all the repos where the stock is being posted as collateral and calculate the equal-weighted average of these repos' characteristics. The repo characteristics variables include: the size of the repo, the equal-weighted number of collateral per repo, the value-weighted number of collateral per repo, the collateral weight of the stock, dummy for Fidelity funds' repos, and dummy for Morgan Stanley funds' repos. We then group the stocks into four categories based on their amount at the end of each month: below 1 million, from 1 million to 10 million, from 10 million to 100 million, and above 100 million. The average repo statistics associated with the stocks in each categories are reported.

Table 9: Top fund families and dealers in the Treasury tri-party repo market

Panel A: Top ten fund families

				repo haircut (%)					repo spread (bps)					repo maturity (#days)					repo size ($m)				
fund family	#repos	amt ($B)	#dealers	mean	std	P10	med	P90	mean	std	P10	med	P90	mean	std	P10	med	P90	mean	std	P10	med	P90
Federated Investors	1,135	347	20	2.02	0.07	2.00	2.00	2.03	1.40	4.40	-4.00	1.00	7.00	1.8	1.7	1	1	5	306	555	8	100	1000
Dreyfus	1,259	300	18	2.00	0.02	2.00	2.00	2.01	1.90	4.60	-5.00	2.00	8.00	1	0	1	1	1	239	353	16	100	650
Blackrock	1,804	265	15	2.00	0.09	2.00	2.00	2.02	1.30	4.70	-5.00	1.00	8.00	1.3	1.7	1	1	2	147	235	5	50	386
Morgan Stanley	1,228	195	22	2.06	0.39	1.86	2.01	2.25	2.10	4.50	-3.00	2.00	7.00	2.2	5.1	1	1	3	159	163	15	100	385
US Bancorp	359	173	15	2.00	0.00	2.00	2.00	2.00	1.20	4.20	-4.00	1.00	7.00	1.1	0.6	1	1	1	482	438	97	312	1000
JP Morgan	354	150	12	2.01	0.04	2.00	2.00	2.00	2.60	4.70	-4.00	3.00	8.00	1.6	1.3	1	1	4	423	349	100	300	1000
Northern Trust	661	130	14	1.92	0.47	1.26	2.00	2.22	2.20	4.50	-3.00	2.00	8.00	1.6	1.8	1	1	4	197	245	9	85	575
Wells Fargo	419	130	17	2.00	0.05	2.00	2.00	2.00	2.50	4.70	-3.90	3.10	9.50	2.3	12.1	1	1	1	311	277	41	250	750
Goldman Sachs	326	124	22	2.07	0.27	2.00	2.00	2.03	1.60	4.80	-6.00	1.00	8.00	2.1	4.9	1	1	2	380	425	21	250	850
Bank of America	546	118	20	2.01	0.14	2.00	2.00	2.00	1.50	4.70	-5.00	2.00	8.00	3.7	9.4	1	1	5	215	187	50	160	460

Panel B: Top ten dealers

				dealer CDS (bps)		repo haircut (%)					repo spread (bps)					repo maturity (#days)					repo size ($m)				
dealer	#repos	amt ($B)	#FFs	mean	std	mean	std	P10	med	P90	mean	std	P10	med	P90	mean	std	P10	med	P90	mean	std	P10	med	P90
BCS	2,496	534	11	164	39.3	1.99	0.21	2.00	2.00	2.03	1.80	4.80	-4.00	2.00	8.00	1.4	1.5	1	1	3	214	369	10	98	500
RBS	1,123	290	11	240	66.8	2.02	0.15	2.00	2.00	2.02	1.80	4.50	-3.00	1.00	8.00	1.5	2.9	1	1	1	259	378	12	110	725
DB	1,506	252	11	138	39.6	1.99	0.24	2.00	2.00	2.00	2.50	4.60	-3.00	4.00	7.40	1.5	3.2	1	1	1	167	250	14	80	456
CS	1,468	230	11	125	32.5	2.03	0.16	2.00	2.00	2.04	1.80	4.70	-4.00	2.00	8.00	2.3	6.1	1	1	3	157	210	12	85	400
BNP	699	215	10	164	58.2	1.97	0.17	2.00	2.00	2.02	1.50	4.60	-4.00	1.00	8.00	1.4	5.2	1	1	1	308	360	15	200	750
BAC	1,465	177	10	190	93.4	2.02	0.40	1.98	2.00	2.06	-0.10	4.20	-5.00	-0.90	5.00	1.9	4	1	1	3	121	168	9	59	300
HBC	873	175	11	118	25.2	2.02	0.14	2.00	2.00	2.04	1.80	4.70	-4.00	2.00	7.00	1.2	0.7	1	1	1	201	256	12	100	500
ACA	377	141	8	218	63.2	2.04	0.39	1.93	2.00	2.14	2.70	3.90	-2.00	3.00	8.00	1.3	3.3	1	1	1	374	592	15	150	1200
GLE	254	92	10	224	76.5	2.00	0.14	2.00	2.00	2.06	2.40	4.30	-3.00	2.00	8.00	1.2	0.8	1	1	1	363	361	29	223	1000
C	517	87	11	130	49.2	2.10	0.52	2.00	2.00	2.11	2.10	4.50	-4.00	2.00	8.00	1.1	0.6	1	1	1	169	193	11	100	450

This table reports the summary statistics of haircut, spread, maturity and size of the Treasury tri-party repos from November 2010 to August 2013. Panel A reports the summary statistics for the top ten fund families and Panel B reports the summary statistics for the top ten dealers. The top ten dealers are Barclays (BCS), Royal Bank of Scotland (RBS), Deutsche Bank (DB), Credit Suisse (CS), BNP Paribas (BNP), Bank of America (BAC), HBSC (HBC), Credit Agricole (ACA), Societe Generale (GLE) and Citi Group (C), respectively. In addition, we also report the mean and standard deviation of the dealers' five-year CDS spreads in Panel B. The CDS spreads data are obtained from Markit, Inc.

Table 10: Characteristics of Treasury collateral by fund families

fund family	#cols (ew)	#cols (vw)	max weight	vol	bill	note	bond	coupon	age	mat	outamt	otr
						mean						
Federated Investors	13.19	6.39	0.48	4.43	0.05	0.80	0.15	2.10	2.56	6.08	39.24	11.43
Dreyfus	2.85	1.96	0.83	5.03	0.08	0.77	0.15	2.05	2.15	6.41	42.62	10.46
Blackrock	2.42	1.84	0.85	4.36	0.06	0.79	0.15	2.07	2.43	6.25	40.18	10.59
Morgan Stanley	2.45	1.73	0.82	3.67	0.06	0.81	0.13	1.97	2.78	5.19	38.83	11.75
US Bancorp	6.80	3.66	0.62	5.36	0.10	0.68	0.22	2.19	2.54	7.65	43.08	9.89
JP Morgan	3.70	2.61	0.69	4.93	0.04	0.77	0.19	2.47	3.28	6.58	39.15	10.89
Northern Trust	2.30	1.69	0.80	4.90	0.02	0.88	0.10	2.08	2.10	6.29	42.04	10.51
Wells Fargo	3.20	2.56	0.65	4.08	0.07	0.81	0.13	2.04	2.42	5.68	40.39	10.54
Goldman Sachs	4.81	3.24	0.67	4.49	0.05	0.83	0.12	2.05	1.86	6.17	40.55	10.44
Bank of America	4.64	2.65	0.74	4.16	0.05	0.83	0.12	2.19	2.56	5.64	38.34	11.36
All	3.83	2.35	0.80	4.43	0.06	0.79	0.15	2.05	2.39	6.21	40.47	10.83
						median						
Federated Investors	4.00	2.99	0.41	3.35	0.00	1.00	0.00	1.91	1.92	4.41	36.13	10.70
Dreyfus	1.00	1.00	1.00	3.25	0.00	1.00	0.00	1.75	1.08	4.17	36.33	8.77
Blackrock	1.00	1.00	1.00	2.30	0.00	1.00	0.00	1.75	1.42	3.71	35.66	9.00
Morgan Stanley	1.00	1.00	1.00	2.07	0.00	1.00	0.00	1.50	1.52	3.16	35.36	10.73
US Bancorp	2.00	1.93	0.63	3.26	0.00	0.90	0.00	1.86	1.48	4.32	36.60	9.25
JP Morgan	2.00	1.69	0.73	3.41	0.00	1.00	0.00	2.29	1.88	4.42	35.59	9.60
Northern Trust	2.00	1.10	0.95	2.91	0.00	1.00	0.00	1.93	1.54	4.47	35.66	8.93
Wells Fargo	2.00	1.83	0.66	2.56	0.00	1.00	0.00	1.77	1.54	4.06	36.21	10.74
Goldman Sachs	2.00	1.71	0.71	2.97	0.00	1.00	0.00	2.00	1.24	4.02	36.34	9.20
Bank of America	2.00	1.36	0.84	2.71	0.00	1.00	0.00	1.89	1.60	4.04	35.27	10.76
All	1.00	1.00	1.00	2.52	0.00	1.00	0.00	1.75	1.39	3.83	35.83	9.58
						standard deviation						
Federated Investors	29.17	11.28	0.32	3.83	0.16	0.30	0.26	1.27	2.65	5.41	14.30	6.93
Dreyfus	10.99	4.16	0.26	5.13	0.25	0.38	0.32	1.65	3.41	7.15	22.06	8.63
Blackrock	6.64	3.63	0.24	4.82	0.22	0.37	0.32	1.62	3.30	7.24	19.37	8.44
Morgan Stanley	4.42	1.74	0.24	4.30	0.21	0.35	0.30	1.68	3.99	6.04	18.63	8.45
US Bancorp	16.26	5.44	0.32	5.47	0.25	0.39	0.36	1.64	3.30	8.04	20.53	7.17
JP Morgan	5.54	3.25	0.30	4.56	0.18	0.36	0.33	1.77	4.30	6.53	17.85	7.73
Northern Trust	1.95	1.35	0.24	4.75	0.14	0.29	0.27	1.27	2.43	6.21	16.49	7.99
Wells Fargo	2.84	2.49	0.28	4.23	0.20	0.32	0.27	1.43	3.08	5.83	16.41	6.90
Goldman Sachs	9.92	4.85	0.32	4.45	0.19	0.33	0.28	1.23	2.12	6.78	15.66	7.98
Bank of America	16.42	5.44	0.28	4.05	0.18	0.32	0.27	1.52	3.28	5.84	16.50	7.73
All	13.90	5.28	0.28	4.80	0.21	0.37	0.32	1.60	3.38	7.01	19.26	8.33

This table reports the summary statistics for the collateral of the Treasury tri-party repos from November 2010 to August 2013. For each Treasury repo, we calculate the number of collateral (#cols (ew)), the value-weighted number of collateral (#cols (vw)), the maximum weight of collateral (col max weight) the proportion of Treasury Bills (bill), the proportion of Treasury Notes (note), the proportion of Treasury Bonds (bond), the value-weighted coupon in percentages (coupon), the value-weighted age in years (age), the value-weighted maturity in years (mat), the value-weighted duration (duratn), and the value-weighted outstanding amount in billions (outamt) and the percentage of on-the-run Treasuries (otr). All the weights are the collateral value of the individual securities divided by the total collateral value. We then report the cross-sectional mean, median and standard-deviation for repos by each fund family and for repos of the full sample.

Table 11: Determinants of haircuts and spreads for Treasury tri-party repos

	haircuts				spreads			
col max weight			0.012	0.003			0.118	0.191
			[0.66]	[0.18]			[0.46]	[0.65]
col coupon			-0.007	-0.009			-0.095	-0.064
			[-1.16]	[-1.50]			[-1.01]	[-0.75]
col age			-0.001	0.001			0.039	0.033
			[-0.23]	[0.48]			[1.01]	[0.88]
col outamt			0.061	0.12			0.104	0.516
			[0.17]	[0.37]			[0.03]	[0.16]
col duratn			0.001	0.002			0.059	0.047
			[0.35]	[1.36]			[1.94]	[1.44]
col bill			-0.075	-0.031			0.49	0.545
			[-1.37]	[-0.75]			[0.99]	[0.90]
col note			-0.056	-0.027			0.7	0.712
			[-1.64]	[-1.17]			[1.93]	[1.70]
col otr			-0.036	-0.027			-0.642	-0.314
			[-1.67]	[-1.04]			[-1.35]	[-0.61]
dealers' CDS		0.017	0.018	0.019		-0.267	-0.276	-0.189
		[0.67]	[0.72]	[0.80]		[-1.63]	[-1.70]	[-1.18]
repo size	-0.015	-0.009	-0.008	-0.001	0.366	-0.037	-0.024	0.018
	[-1.53]	[-1.35]	[-1.21]	[-0.39]	[1.71]	[-0.56]	[-0.38]	[0.48]
repo term	-0.015	-0.009	-0.005	-0.004	-1.844***	-1.906***	-1.875***	-1.858***
	[-0.91]	[-0.47]	[-0.28]	[-0.48]	[-3.30]	[-3.93]	[-3.96]	[-4.21]
repo maturity	0.001	0.001	0.001	0.001	0.027**	0.025**	0.025**	0.016
	[-0.19]	[-0.46]	[-0.41]	[-0.50]	[2.17]	[2.20]	[2.18]	[1.72]
month dummies	Y	Y	Y	Y	Y	Y	Y	Y
dealer dummies	N	Y	Y	Y	N	Y	Y	Y
fund family dummies	N	N	N	Y	N	N	N	Y
nobs	15436	14849	14849	14849	15436	14849	14849	14849
adj R2	1.8	5.4	5.8	14.4	59.5	71.9	72.0	75.0

This table reports the OLS regressions on the haircuts and spreads of the Treasury tri-party repos from November 2010 to August 2013. The collateral characteristics variables are defined in Table 10. Other control variables include dealers five-year CDS spreads, repo size, dummy for term repo, repo maturity, dummies for months, dealers, and fund families, respectively. The t-statistics reported in squared brackets are based on the standard errors double clustered by months and fund families, and, ** and *** denote significance at the 5% and 1% level.

Table 12: Top fund families in the corporate bond repo market

Panel A: High-yield corporate bond repos

				haircut (%)		spread (bps)		maturity (#days)		size ($m)		#cols (ew)		#cols (vw)		col max weight		col maturity		col rating	
fund family	#repos	amt ($m)	#dealers	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med
Fidelity	493	38,749	14	8.03	8.01	42.68	40.00	8	4	79	17	7.3	2.0	3.7	1.2	0.7	0.9				
Federated Investors	70	7,226	3	2.05	2.00	36.14	38.00	4	4	103	100	32.3	31.0	13.8	13.7	0.2	0.2	7.0	6.0	13.5	13.5
Morgan Stanley	110	5,513	10	5.77	5.97	36.55	36.00	16	3	50	38	42.9	16.5	16.0	6.9	0.3	0.3	8.0	7.0	14.2	14.0
Blackrock	67	5,174	5	6.93	7.00	34.13	39.00	3	1	77	65	43.7	35.0	23.8	24.8	0.1	0.1	7.3	6.8	14.0	14.3
Bank of America	41	3,362	3	5.12	5.00	17.63	12.00	10	1	82	64	24.7	20.0	7.8	8.5	0.4	0.2	6.0	5.8	10.7	10.5

Panel B: Investment-grade corporate bond repos

				haircut (%)		spread (bps)		maturity (#days)		size ($m)		#cols (ew)		#cols (vw)		col max weight		col maturity		col rating	
fund family	#repos	amt ($m)	#dealers	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med	mean	med
Fidelity	827	57,926	15	5.04	5.02	24.98	22.00	6	4	70	14	8.1	4.0	3.9	1.6	0.7	0.8				
Bank of America	374	32,246	14	4.57	5.00	17.65	15.50	9	1	86	63	30.3	15.0	11.5	6.4	0.4	0.3	4.6	5.0	6.4	7.8
Morgan Stanley	140	18,396	10	5.01	5.00	14.65	12.00	2	1	131	60	91.6	19.5	53.3	10.6	0.3	0.1	10.3	9.9	7.7	7.5
Blackrock	95	8,175	7	6.54	7.00	19.28	15.00	6	1	86	50	65.9	38.0	29.9	24.1	0.1	0.1	11.0	10.3	8.0	8.2
Barclay	38	5,869	5	3.80	3.07	13.08	11.00	2	1	154	120	48.8	19.0	19.7	10.3	0.2	0.2	8.7	7.0	7.9	8.3

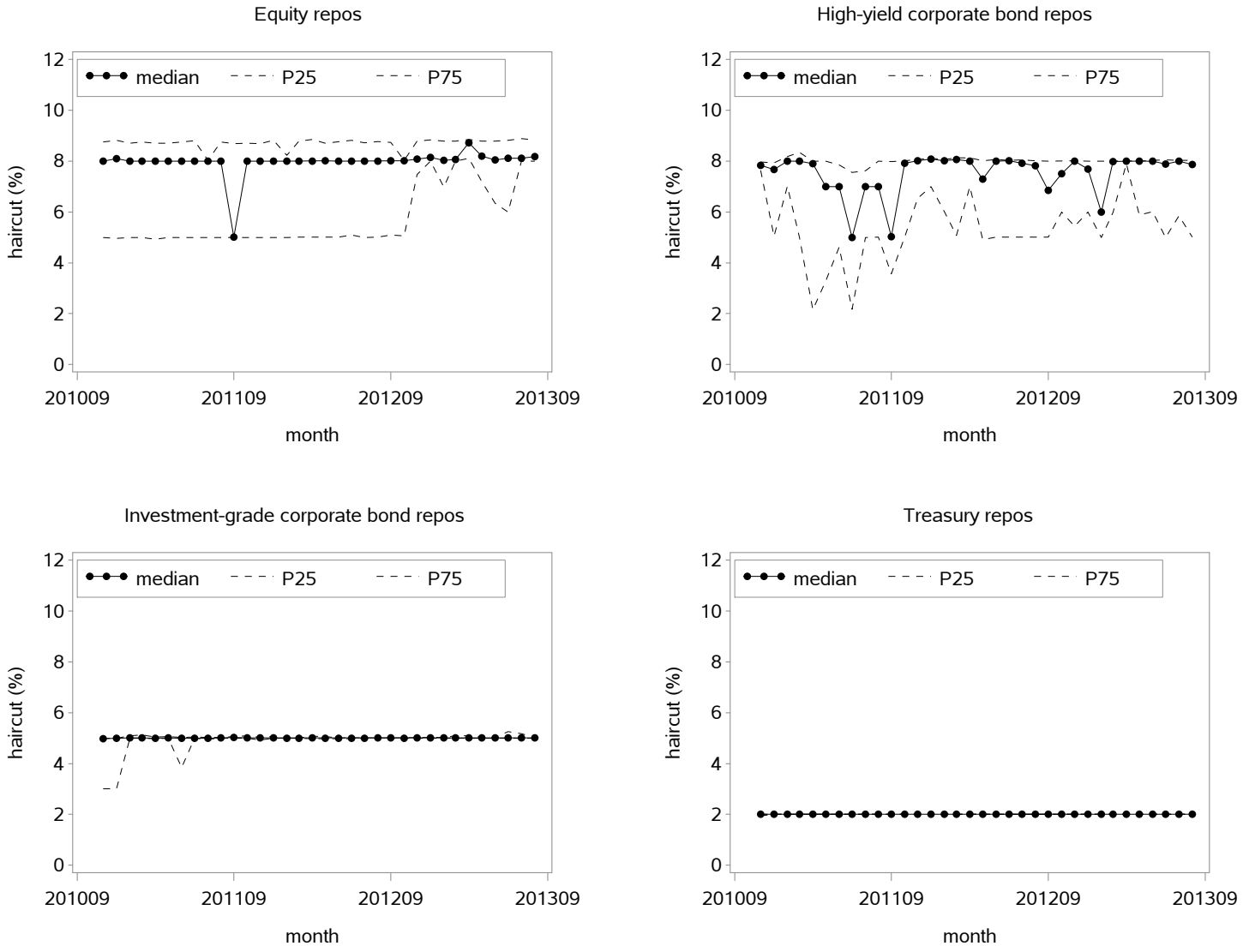
This table reports the summary statistics of haircut, spread, maturity, size, and collateral characteristics of the corporate bond tri-party repos from November 2010 to August 2013. The collateral characteristics variables include the equal-weighted number of collateral per repo (#cols (ew)), the value-weighted number of collateral per repo (#cols (vw)), the maximum weights of collateral per repo (col max weight), the value-weighted collateral maturity (col maturity), and the value-weighted collateral rating (col rating). The weights are calculated as the value of individual collateral divided by the total collateral value of a repo. The ratings are numerical numbers based on Moody's corporate bond ratings, from Aaa (1) to C (21). Panel A reports the summary statistics for the top five fund families in the high-yield corporate bond repo market and Panel B reports the summary statistics for the top five fund families in the investment-grade corporate bond repo market.

Table 13: Determinants of haircuts and spreads for corporate bond tri-party repos

	Panel A: High-yield corporate bond repos					
	haircuts			spreads		
col max weight	1.168***			3.112**		
	[4.96]			[2.35]		
col maturity		0.16			0.012	
		[1.28]			[0.02]	
col rating			0.067			0.169
			[1.10]			[0.70]
dealers' CDS	0.021***	0.021**	0.019	0.017	-0.029	-0.03
	[3.04]	[2.26]	[1.94]	[0.50]	[-0.71]	[-0.67]
repo size	-0.091**	-0.096	-0.125	0.338	1.556***	1.511***
	[-2.52]	[-0.89]	[-1.11]	[1.68]	[3.79]	[4.01]
repo term	-0.272	-0.467	-0.396	7.920***	1.981	2.063
	[-0.86]	[-1.27]	[-1.02]	[4.17]	[0.60]	[0.65]
repo maturity	0.004	0.004	0.004	0.146**	0.201**	0.195**
	[0.96]	[0.27]	[0.27]	[2.12]	[2.05]	[1.99]
month dummies	Y	Y	Y	Y	Y	Y
dealer dummies	Y	Y	Y	Y	Y	Y
NOBS	654	188	188	654	188	188
R2	51.7	71.7	71.1	61.3	58.3	58.4
	Panel B: Investment-grade corporate bond repos					
	haircuts			spreads		
col max weight	-0.069			1.143		
	[-0.84]			[1.55]		
col maturity		0.101			-0.163	
		[1.35]			[-0.31]	
col rating			0.019			-0.233
			[1.04]			[-1.47]
dealers' CDS	0.001	0.002	0.002	0.015	-0.008	-0.013
	[0.81]	[0.74]	[0.50]	[0.91]	[-0.50]	[-0.77]
repo size	-0.025	-0.006	-0.016	-0.322***	0.596	0.576
	[-1.62]	[-0.06]	[-0.17]	[-2.79]	[1.39]	[1.48]
repo term	0.360***	-0.03	0.012	9.173***	11.259***	11.486***
	[2.69]	[-0.14]	[0.07]	[4.74]	[9.32]	[12.02]
repo maturity	-0.004**	0.004	0.001	0.182***	0.146***	0.138***
	[-2.36]	[0.90]	[0.40]	[5.89]	[4.20]	[5.18]
month dummies	Y	Y	Y	Y	Y	Y
dealer dummies	Y	Y	Y	Y	Y	Y
NOBS	1140	278	278	1134	272	272
R2	39.4	60.9	59.6	70.6	80.0	80.7

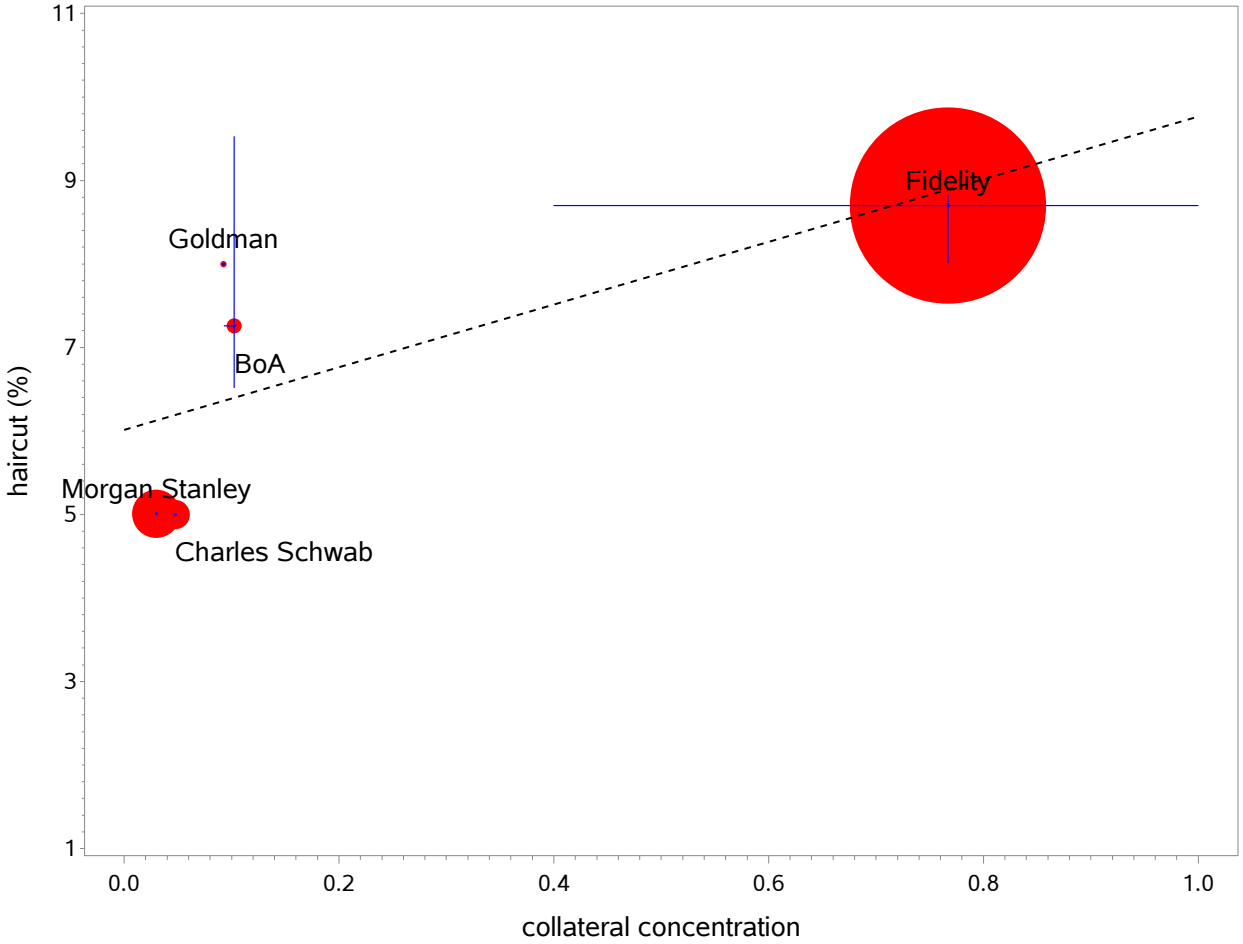
This table reports the OLS regressions on the haircuts and spreads of tri-party repos on high-yield and investment-grade corporate bond repos. The sample period is from November 2010 to August 2013. The collateral characteristics variables include the maximum collateral weight per repo (col max weight), the value-weighted bond maturity (col maturity), and the value-weighted bond rating (col rating). The weights are the collateral value of the securities in the collateral pool divided by the total collateral value. Other control variables include dealers five-year CDS spreads, repo size, dummy for term repo, repo maturity, dummies for months and dealers, respectively. The t-statistics reported in squared brackets are based on the standard errors clustered by months, and, ** and *** denote significance at the 5% and 1% level.

Figure 1: Distribution of repo haircuts by asset classes.



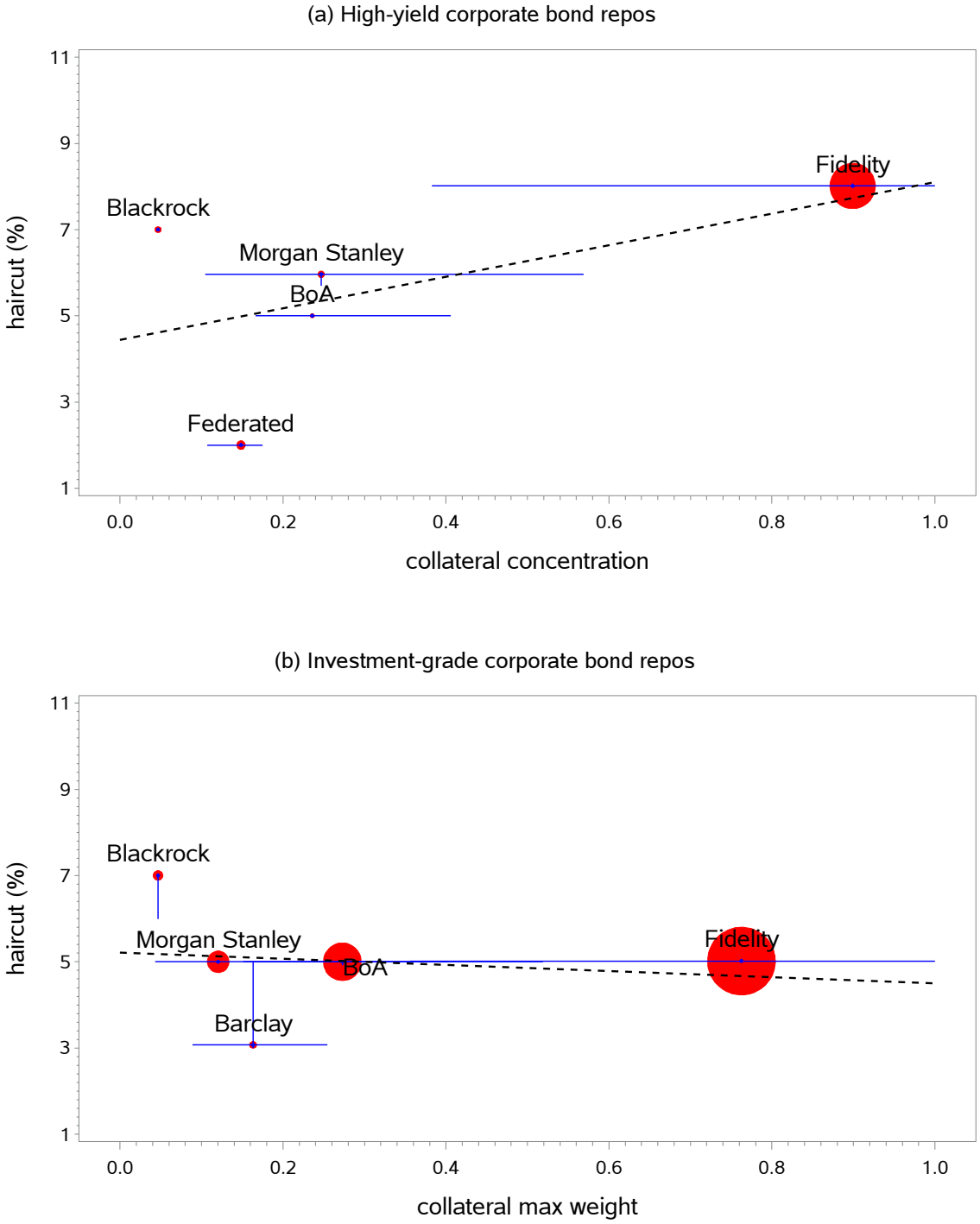
This plot shows the 25% percentile (P25), the median, and the 75% percentile (P75) of repo haircuts at the end of each month from November 2010 to August 2013. The statistics are calculated based our collected sample of tri-party repos with matched collateral information.

Figure 2: Collateral concentration and haircuts for equity repos



For each fund family, the blue vertical line represents the range from the 25% percentile to the 75% percentile of the haircuts; the blue horizontal line represents the range from the 25% percentile to the 75% percentile of the collateral concentration, measured as the maximum weight of securities in a collateral pool; the horizontal line and the vertical line intersects at the median of haircuts and collateral concentration. In addition, we also plot a red filled circle centered at the median of the haircuts and collateral concentration for each of the fund families, where the size of the circle is proportional to the market share of the fund families.

Figure 3: Collateral concentration and haircuts for corporate bond repos



For each of the top five fund families in the high-yield and investment-grade corporate bond repo markets, the blue vertical line represents the range from the 25% percentile to the 75% percentile of the haircuts; the blue horizontal line represents the range from the 25% percentile to the 75% percentile of the collateral concentration, measured as the maximum weight of securities in a collateral pool; the horizontal line and the vertical line intersects at the median of the haircuts and the collateral concentration. In addition, we also plot a red filled circle centered at the median of the haircuts and the collateral concentration for each of the fund families, where the size of the circle is proportional to the market share of the fund families.