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Regulatory Arbitrage in Repo Markets

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Abstract

Non-U.S. banks with relatively low capital ratios appear to temporarily remove an average of $170 billion from the U.S. market for tri-party repurchase agreements (repo) before each quarter-end in order to appear safer and less levered. This amount is more than double the $76 billion market-wide drop in tri-party repo during the turmoil of the 2008 financial crisis and represents about 10% of the entire tri-party repo market. Such window dressing-induced deleveraging spills over into agency bond markets and money market funds and affects market liquidity each quarter.

*The views expressed in this paper are solely those of the author and do not necessarily reflect the position of the Office of Financial Research (OFR), the U.S. Department of the Treasury, the U.S. Securities and Exchange Commission, the Financial Industry Regulatory Authority, the Federal Reserve Board of Governors, or the Federal Reserve Bank of New York. This paper uses confidential tri-party repo data to study market activity but does not reveal identities or positions of individual market participants.

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Introduction

I investigate the stability and composition of the repurchase agreement (repo) market and how window dressing creates spillovers and affects systemic risk. Window dressing is the practice in which financial institutions adjust their activity around an anticipated period of oversight or public disclosure to appear safer or more profitable to outside monitors. The repo market is a form of securitized banking that provides critical overnight funding for the financial system but is vulnerable to runs. Several studies have suggested that instability in the repo market—whether through a margin spiral effect in bilateral repo or a run on individual institutions by their repo lenders in tri-party—helped cause the 2008 financial crisis.[1][2] Its short-term nature means the repo market can also accommodate window dressing, or temporary adjustments around a reporting period. However, like most two-sided markets, it is difficult for outsiders to identify whether a change in repo market activity is due to window dressing or rather to normal changes in the underlying supply and demand of that market. I combine data sources for both supply and demand factors in the repo market to overcome this problem and show that a type of repo market window dressing has continued to occur among non-U.S. bank dealers each quarter since the 2008 financial crisis, and this window dressing creates spillover effects in other markets.

My primary data source is confidential regulatory reports on daily tri-party repo transaction summaries since July 2008, obtained from the Federal Reserve Board of Governors (Federal Reserve) and the U.S. Treasury Office of Financial Research. Tri-party repo is the ultimate source of cash financing for many other repo transactions, and by extension much

[1] See for example Gorton and Metrick (2012), Krishnamurthy, Nagel, and Orlov (2014), Copeland, Martin, and Walker (2011), Martin, Skeie, and von Thadden (2014), and Ivashina and Scharfstein (2010).

[2] The window dressing described in this paper is different from the "Repo 105" program that Lehman Brothers used in 2008 to hide its actual leverage. In that program, Lehman accepted a relatively high 5% haircut in order to count its repo transactions as "true sales," allowing it to significantly reduce its reported leverage, even though it remained under a contractual obligation to repurchase those assets. In contrast, the non-U.S. dealers whose activities are described in this paper appear to be selling assets before the quarter-end and then re-acquiring them after .I find no evidence that they are simply raising haircuts and, although they tend to re-acquire those assets once a new quarter starts, I do not discover any obligation on their part to do so.

of the shadow banking system. This dataset covers the entire $1.7 trillion tri-party repo market, includes details on how much a dealer (a "cash borrower") borrows using each type of collateral, and shows how costly it is for the dealer to borrow each day. It also includes data starting from January 2011 on the network of daily repo borrowing between dealers and the various institutions that are their repo counterparties ("cash lenders"). In a time series regression controlling for dealers' home regions, I show that broker-dealer subsidiaries of non-U.S. banks use repo to window-dress roughly $170 billion of assets each quarter, in what appears to be a form of regulatory arbitrage.

In Figure 1, I plot the daily tri-party repo borrowing to highlight this window dressing. Each quarter-end is marked with a vertical gridline, and there is a pronounced decline and subsequent rebound each quarter around that line. The steepness and width of that pattern varies somewhat each quarter, but on average it represents about 10% of the entire tri-party repo market. This quarterly decline is separate from longer-duration market trends: there was a steep decline in repo borrowing following the 2008 financial crisis, but the market gradually increased until the end of 2012. Since then the market has steadily declined—likely due to the Federal Reserve's asset purchases via quantitative easing (QE), which has increased the scarcity of safe liquid assets typically financed in repo.[3]

I further examine where this decline in repo occurs by looking across dealers and across types of repo collateral. I find that repo declines are concentrated in the broker-dealer subsidiaries of non-U.S. bank holding companies, using primarily U.S. Treasuries and agency securities. These results suggest a window dressing-based explanation for the phenomenon. U.S. banks report the quarter average as well as quarter-end balance sheet data and ratios, whereas non-U.S. banks only report quarter-end data. This regulatory difference seems to explain why U.S. bank dealers don't window-dress: U.S. banks have little incentive to

[3]For more on QE's effects on the repo market, see the online note by Elamin and Bednar (2014): http://www.clevelandfed.org/research/trends/2014/0414/01banfin.cfm

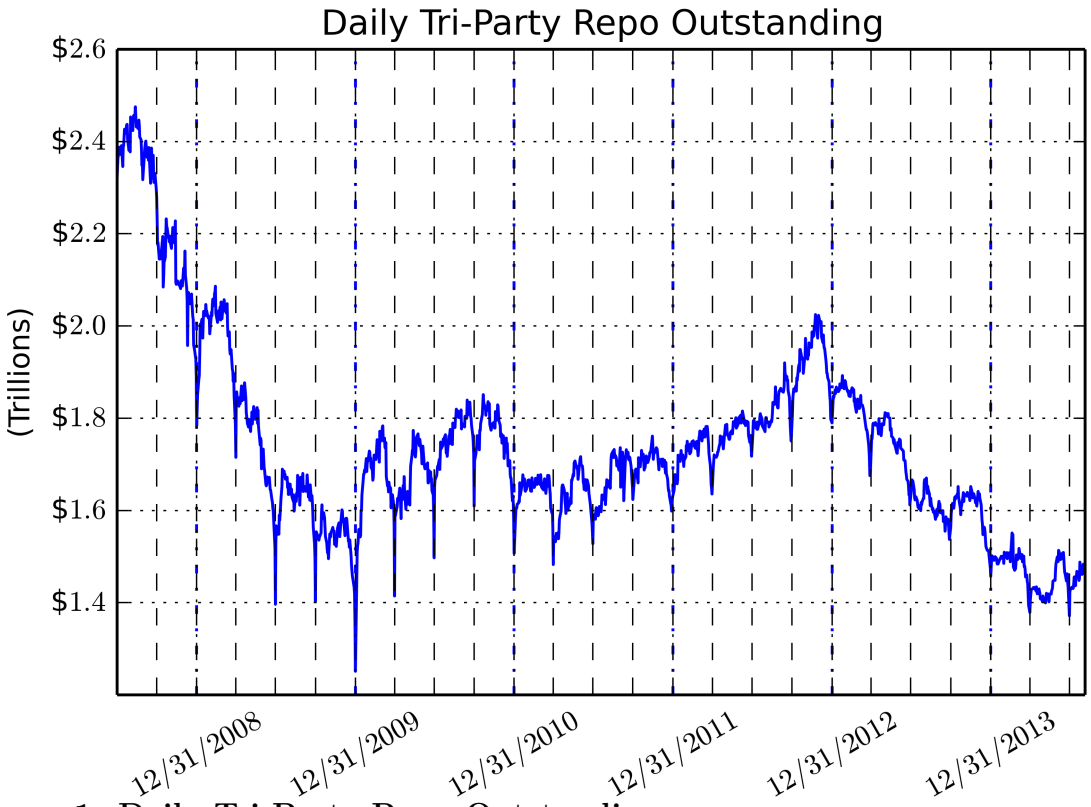

Figure 1. Daily Tri-Party Repo Outstanding

Notes: The vertical axis represents the value in trillions of dollars of collateral outstanding pledged in repo each day from July 1, 2008 to July 31, 2014. Quarter-ends are marked with vertical dashed lines, and year-ends are marked with heavier dash-dotted lines. I exclude repo borrowing by the Federal Reserve Bank of New York, and I exclude the dates of 7/17/2008 and 4/11/2013 because of missing data from one of the clearing banks.
Source: Federal Reserve Board of Governors

window-dress at the end of the quarter compared to any other time during the quarter. Previous studies such as Owens and Wu (2012) and Downing (2012), which use quarterly data or U.S. bank holding company data, find at best a mild quarter-end effect, precisely because dealer bank window dressing occurs in just a few days and is mostly done by non-U.S. banks (see Figure 2). Moreover, when I investigate their sample further in section 5.3, I find that the window-dressing explanation is only significant for bank holding companies whose ultimate parent resides outside the U.S., and quarter-end variations by U.S. banks can be explained by business, not regulatory, concerns.

Banks with dealer subsidiaries face multiple regulatory requirements which affect their repo activity. For example, capital adequacy requirements for agency mortgage-backed securities guaranteed by Fannie Mae and Freddie Mac (which represent the single largest category of collateral pledged in tri-party repo) receive a 20% risk weight.[4] This means banks have to hold significant capital against the value of these securities, and some bank managers view capital as expensive. Further, the liquidity coverage ratio (LCR) mandates that banks maintain a level of highly liquid assets valued at least 100% of their expected cash outflows over 30 days in a stress scenario. However, again agency securities are classified as Level 2a assets, meaning they face a 20% haircut in their valuation towards satisfying the LCR.

Additionally, many banks operate in the repo market on a "matched book" principle, where the bank makes overnight cash loans to clients and finances those loans by borrowing that money from the tri-party repo market. However, the net stable funding ratio (NSFR) requirement demands banks finance 10% of the value of their repo cash lending transactions with longer-term "stable funding." The NSFR does not allow the bank to count its own cash borrowings from the repo market as stable funding, which means the bank must find alternative and potentially costlier sources of financing. Instead, a bank that is only monitored at quarter ends may choose to simply wind down the "matched book" around those days, reducing both their repo borrowing and lending, to satisfy the NSFR requirement.

[4]see https://www.fdic.gov/news/news/financial/2012/fil12027.html

This is problematic because the NSFR was designed to prevent a contagion scenario in the dealer system, where dealers lose unstable funding sources in a crisis and are forced to withdraw credit to their clients. During the interim period between monitoring, a bank may be operating above the NSFR and reducing the effectiveness of these regulatory safeguards.

I establish that the decline in repo is caused by the non-U.S. bank dealers—not their repo lenders—by combining this data with reports on money market mutual fund portfolio holdings and assets under management from iMoneyNet and the U.S. Securities and Exchange Commission (SEC) form N-MFP, and quarterly bank parent balance sheet data from Bankscope. I then perform a joint estimation of supply and demand in the repo market and find that a non-U.S. dealer's quarter-end window dressing is strongly predicted by its leverage the prior quarter. To further identify causality, I use network data of repo funding between dealers and cash lenders to perform a within-lender regression that controls for potential omitted cash supply factors.

I show significant spillover effects from repo window dressing to other markets. If non-U.S. bank dealers window-dress to report lower leverage, then when they withdraw collateral from repo, they must also sell those assets. I use the Financial Industry Regulatory Authority's (FINRA) Trade Reporting and Compliance Engine (TRACE) Agency bond transaction-level data from 2010 to 2013 in a time series regression with time-fixed effects for each quarter[5] to test whether dealers are trading abnormally around the end of the quarter. I find that dealers sell heavily to customers in the last days of the quarter and immediately buy agency bonds back once the new quarter starts. In an empirical test of the theoretical findings of Froot and Stein (1998), I find that this self-imposed deleveraging causes a significant change in the market quality for agency bonds at quarter-end.

At the same time, declines in repo borrowing due to window dressing leave cash lenders

[5]Because the days around a quarter-end will span two quarters, and because there is a pronounced downward trend in the overall repo market over my sample, there may be concern that using quarter fixed effects will bias the estimates for repo borrowing at the end of an old quarter and the start of a new one away from each other, overstating this window dressing result as an artifact of my methodology. As a robustness test, I have estimated these results with year fixed effects and by shifting the fixed effects reference 1 month forward, as well as without any fixed effects at all, and the results persist in both magnitude and significance.

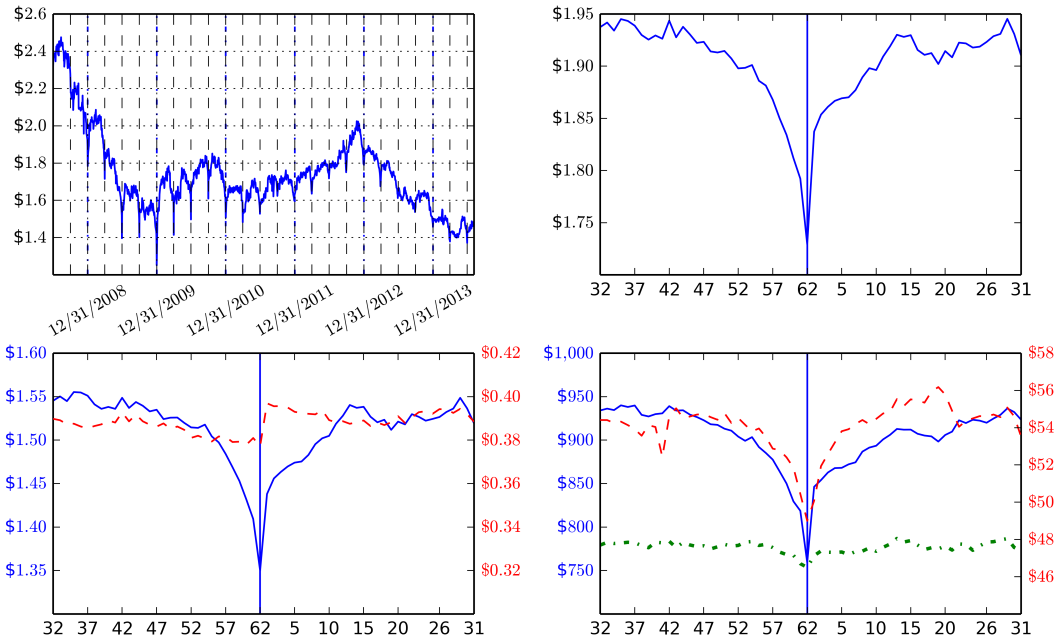

Figure 2. Repo Borrowing at the End of an Average Quarter

(Top left): I include a copy of Figure 1, with trillions of dollars in daily repo borrowing, as a reference.
(Top right): This figure represents the average daily repo outstanding over the course of a single quarter. The average quarter has 62 trading days, and I position the end of the quarter (marked by a vertical line) in the middle of the figure to highlight the quarter-end decline and subsequent rebound of repo borrowing. The vertical axis again represents the market value of collateral in trillions of dollars.
(Bottom left): I separate the average repo outstanding over a single quarter by type of asset. The solid blue line uses the left axis and represents average repo borrowing backed by the safest collateral: U.S. Treasuries, agency debentures, and agency mortgage-backed securities, and agency collateralized mortgage obligations. The dotted red line uses the right axis and represents average repo borrowing backed by all other types of collateral. Both axes are in trillions of dollars.
(Bottom right): Here I present the average repo outstanding over a single quarter separated by the region of the repo cash borrower (i.e., the dealer that is pledging collateral in the repo). The left and right axes are both in billions of dollars. I exclude non-bank dealers from this subplot. The dotted green line represents repo borrowing by U.S. bank dealers and can also be distinguished by its distinct behavior: this line touches the left axis at roughly $780 billion and does not dip as markedly as the other two lines at the end of the quarter. The solid blue line represents repo borrowing by European bank dealers. Both U.S. and European bank dealer repo borrowing are in reference to the left axis. The dashed red line shows Japanese bank dealer repo borrowing, and because Japanese bank dealers are a much smaller segment of the repo market, I plot their line using the right axis.
Enlarged individual copies of these figures are included in the appendix.
Source: Federal Reserve Board of Governors

such as money market mutual funds with excess cash that they struggle to invest. My analysis of monthly money market fund (MMF) portfolios shows that despite being able to anticipate window dressing, MMFs are still unable to find any investment at all for about $20 billion of cash each quarter-end before September 2013. The Federal Reserve's reverse repurchase agreement (RRP) program began at that time with the stated intention of being a tool for raising interest rates, but it has become a substitute investment for repo lenders during times of window dressing.

Section 1 of this paper reviews the current state of the literature, and how my findings contribute to an understanding of repo markets and their potential for systemic risk and to the literature on seasonality. Section 2 provides an overview of the repo markets and the tri-party repo market's important position relative to the bilateral and general collateral repo markets. In section 3, I describe the datasets used in this paper, with a particular focus on the regulatory tri-party repo data collection. Section 4 lays out my empirical strategy to identify window dressing and establish dealers as the cause of it. I report the results of robustness tests in Section 5. Section 6 shows how window dressing in repo markets has necessary repercussions in at least two other markets: the market for agency bonds and the money market mutual fund industry. Section 7 concludes with some policy recommendations to prevent future window dressing, or at least mitigate its impact.

1 Literature Review

My paper contributes to existing literature focused on three main areas: the stability of repo markets, seasonality (and its underlying causes), and the risk management of financial intermediaries.

Since 2008, a surge has occurred in the literature that analyzes the role that repo markets played in the financial crisis. Gorton and Metrick (2009, 2012) suggest that haircuts on collateral in bilateral repo created a destabilizing feedback effect, forcing cash borrowers to delever by selling assets in a fire sale, which caused haircuts to rise even higher, precipi-

tating the banking system's insolvency. However Copeland, Martin, and Walker (2011) and Krishnamurthy, Nagel, and Orlov (2014) find that in tri-party repo there is no spiral effect, and the crisis in tri-party repo is more consistent with a run on certain dealers by their cash lenders.

Difficult to determine in this discussion is the direction of causation for the effects these papers describe. Indeed, Gorton and Metrick (2012) admit that "without a structural model of repo markets, we are only able to talk about co-movement... thus we use the language of 'correlation' rather than 'causation' in our empirical analysis." Martin, Skeie, and von Thadden (2014) present a theoretical model of repo lending that extends earlier bank run models from Diamond and Dybvig (1983) and Qi (1994) to analyze runs on collateralized repo borrowing instead of commercial bank deposits. The paper finds that liquidity constraints (the size, short-term leverage, and profitability of a repo borrower), as well as collateral constraints (the value to lenders from taking ownership of repo collateral directly, the productivity of a borrower from continuing to manage collateral, as well as borrower size and short-term leverage) determine a repo borrower's ability to survive a crisis. However, their model also predicts that outside of a crisis, each borrower invests (and borrows) as much as possible.

In this paper I provide evidence that the quarterly decline in repo is not due to a run-type panic, but rather due to repo becoming relatively less profitable at quarter-end for non-U.S. bank dealers. This is consistent with Martin, Skeie, and von Thadden (2014), who suggest that dealers will adjust their repo borrowing to trade off between profitability and liquidity risk constraints. When repo is more profitable, their paper suggests dealers will take more liquidity risk in the quantity and type of collateral they pledge, increasing their exposure to the risk of a run by their cash lenders. Therefore, if there is a shock to collateral again in the future (like the 2007 asset-backed commercial paper crisis), non-U.S. bank tri-party borrowers may be the ones more vulnerable to a run.

This paper adds to extensive literature on seasonality. Since January effects were docu-

mented by Rozeff and Kinney (1976) and Keim (1983), researchers have tried to find underlying explanations for the effect. Ritter (1988) looks at the behavior of investors around the turn of the year and finds individual investors may drive the January effect. Constantinides (1984), Sias and Starks (1997), and Poterba and Weisbenner (2001) look more deeply and find that underlying tax reasons might drive investors' year-end abnormal trading.

Other papers suggest window dressing may explain seasonal effects. Haugen and Lakonishok (1987) suggest the January effect might be explained by fund managers adjusting their portfolios to appear safer for their end-of-year filings. Lakonishok et al. (1991) investigate pension fund managers and find they sell losers in the fourth quarter to make it appear that they are good at picking stocks. In a sample of banks from 1978 to 1986, Allen and Saunders (1992) claim to find upward window dressing, in which banks increase their balance sheet each quarter to appear larger. Musto (1997) finds further support for this by examining the difference in trading behavior of commercial paper and Treasury bills around the year-end, and suggests that intermediaries don't want to show a risky portfolio to regulators or investors. However, Wermers (1999) finds no evidence of window dressing by mutual fund managers at the end of the year versus other quarters. In contrast, I do not see much evidence of January effects in repo, but I do find support for window dressing at the quarterly frequency, which spills over into fixed income markets.

In the repo market specifically, the literature has looked for evidence of window dressing or a liquidity habitat preference. So far the results for window dressing have been mixed. Owens and Wu (2012) and Downing (2012) look at U.S. bank repo behavior at the end of the quarter versus quarter average repo borrowing, and find that banks window-dress modestly at the end of the quarter. However, they are unable to definitively claim that they find window dressing and not just a shift in banks' funding sources. In section 5, I show that controlling for the country of a bank dealer is critical to interpreting their results.

Non-U.S. banks were outside the scope of those previous studies, but it is precisely among non-U.S. bank dealers that I find significant window dressing. U.S. banks report

the quarter-average as well as quarter-end balance sheet data and ratios, whereas non-U.S. banks only report quarter-end data. This regulatory difference may help explain why U.S. bank dealers don't window-dress: U.S. banks have little incentive to window-dress at the end of the quarter compared to any other time during the quarter. Other institutional features, or differences in the regulatory environment inside and outside the U.S. may also contribute to a dealer's decision to window-dress, however, differential monitoring seems likely to be a primary factor.

A series of papers by Griffiths and Winters (1997, 2005) and Kotomin, Smith, and Winters (2008) propose that window dressing does not occur in repo, but, instead, repo declines are driven by a preferred liquidity habitat model as in Modigliani and Sutch (1966). In this scenario banks do not actively reduce their repo borrowing to hide leverage. Instead, cash suppliers, such as money market funds, must cut their repo lending in order to redeem their own investors' outflows. In this paper I provide evidence from two data sources on money market funds that show that money funds do not see outflows nearly as large as the drop in repo outstanding, and, in fact, repo lenders have an excess of cash at the end of the quarter. I further identify the quarterly decline as dealer-driven using a within-investor estimation approach similar to that of Khwaja & Mian (2008), which uses time and investor-fixed effects to control for unobserved demand factors.

Theoretical models by Froot, Scharfstein, and Stein (1993) and Froot and Stein (1998) suggests that capital structure policy plays a critical role in risk management. A key implication of their framework for financial intermediaries (including dealers) is that capital adequacy constraints will generate asymmetric price effects in intermediated markets. When dealers are capital-constrained, they will offer worse prices to trades that tighten capital constraints, and better prices to trades that relax those constraints. Empirical research by Naik and Yadav (2003) uses daily detailed position data on each UK government bond dealer and supports these conjectures.

Recent work by Koijen and Yogo (2013) finds that regulatory arbitrage by financial

intermediaries has real economic effects as well. Their study of U.S. life insurers shows that risk transfers to off-balance-sheet and affiliated entities has the effect of reducing the insurers' risk-based capital, and increases their probability of default by a factor of 3.5. Moreover, they estimate that eliminating this regulatory arbitrage would increase the life insurance prices offered by those companies by 12%, and reduce the overall amount of U.S. life insurance provided to households. Although these effects are much harder to detect during the quarter among bank dealers, who can take risk through a diverse portfolio rather than a single product like life insurance, I present evidence that dealer window dressing does reduce market quality at the quarter-end when non-U.S. dealers are deleveraging.

2 Mechanics of the Repo Markets

This section provides a basic explanation of how a repurchase agreement works, the differences in the institutional operations of each of the three repo markets, and why tri-party repo matters to the financial system. Readers who are already familiar with repo may wish to skip ahead to Section 3.

A repurchase agreement (commonly shortened to "repo") is a contract in which one party sells securities with the agreement to repurchase those same securities at a specified maturity date. The other party pays cash for those securities and promises to return them when the repo matures and receive their cash plus interest, similar to a collateralized loan.

The second party (the cash lender) typically assigns a haircut to the cash amount they pay, relative to the market value of securities received, as protection in case the first party (the cash borrower) defaults and fails to return the cash. A repo is treated legally as a "true sale," which means the repo collateral is exempt from an automatic stay in bankruptcy if the cash borrower defaults, and the cash lender can sell or hold the securities without any encumbrance. However, many cash lenders will accept collateral that their charter or prospectus would not permit them to hold directly—for example, money market mutual funds (MMMFs) lending cash in repo against long-dated mortgage-backed securities (an-

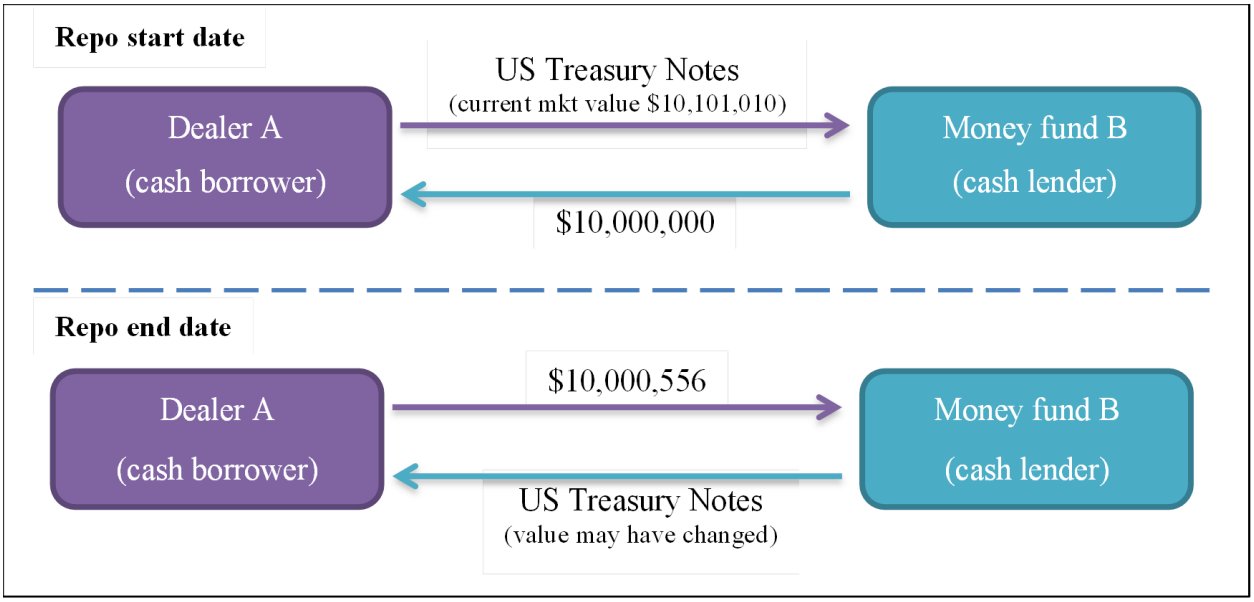

Figure 3. A Sample Repurchase Agreement Transaction

Source: OFR analysis

other form of regulatory arbitrage). A default of the cash borrower could then force the cash lender to immediately sell those securities, regardless of the market liquidity environment. A larger haircut protects cash lenders from potential losses when liquidating collateral in adverse market conditions, as well as from sudden fluctuations in the collateral's value.

Example:

Figure 3 shows a sample repurchase agreement. Dealer A is borrowing $10,000,000 cash overnight from money market fund B at a 2% nominal annual percentage rate, and pledging U.S. Treasury notes as collateral. Dealer A has simultaneously agreed to repurchase the securities the next day from money market fund B for $10,000,556 ($10,000,000 + 2%/360 days * $10,000,000). Money market fund B assesses a 1% haircut against U.S. Treasury collateral pledged by Dealer A, so in order to obtain the $10M cash, Dealer A has pledged U.S. Treasury notes worth $10,101,010 ($10,000,000/99%).

The market for repurchase agreements is divided into three main segments: bilateral, general collateral finance, and tri-party. Figure 4 visually depicts a stylized version of the

flow of cash and collateral between participants in these different types of repo. In subsections 2.1 through 2.3, I offer more details about the key institutional differences and connections between these markets.

2.1 Bilateral Repo Market

The bilateral repo market is unique in that its trades do not settle on the books of the two large clearing banks—Bank of New York Mellon Corp. and JPMorgan Chase & Co. Instead, bilateral repos (also called Delivery versus Payment repos) are negotiated and settled directly between dealers and their clients. Dealers can act as either cash borrowers or cash lenders, and their counterparties are primarily hedge funds and real estate investment trusts (REITs), though banks and other institutions may participate to a smaller extent. The purpose of bilateral is also distinct from tri-party and general collateral finance (GCF) repo: bilateral repo is reportedly driven by market participants' needs to acquire specific securities for hedging or settlement purposes, not just to finance a portfolio. A recent study from the Federal Reserve Bank of New York using primary dealer data estimates U.S. Treasuries currently make up 90% of bilateral repo collateral.[6] The estimated size of the bilateral repo market varies: the Federal Reserve Bank of New York estimates the size of the bilateral repo market at $1.4 trillion, on par with tri-party repo daily volume.

2.2 General Collateral Finance Repo Market

A general collateral finance (GCF) repo is an inter-dealer repo centrally cleared by the Fixed Income Clearing Corporation (FICC) over Fedwire, in which the cash borrower and cash lender directly negotiate a rate and duration for the repo, and specify a *class* of assets (e.g., all mortgage-backed securities, or Treasuries with fewer than five years to maturity)

[6]See note by Copeland, Davis, LeSueur, and Martin (2014): http://libertystreeteconomics.newyorkfed.org/2014/07/lifting-the-veil-on-the-us-bilateral-repo-market.html .

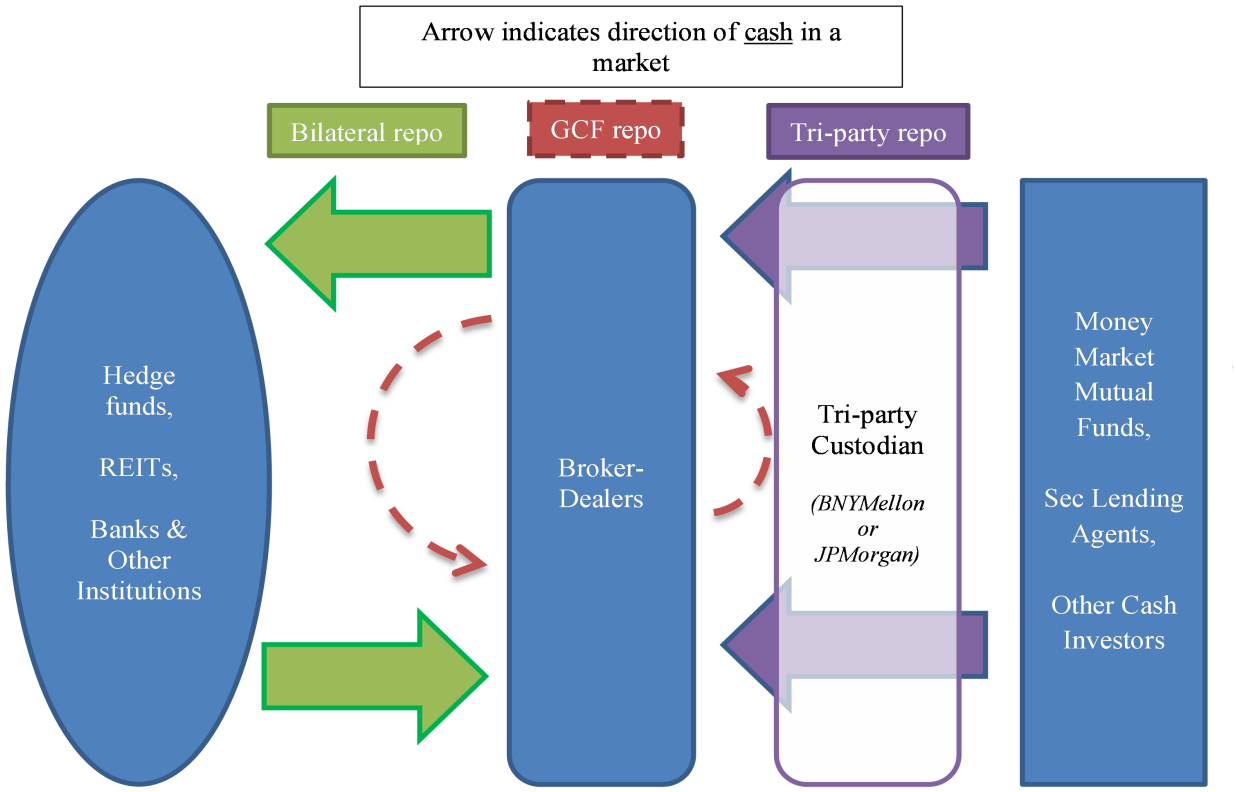

Figure 4. A Stylized Diagram of Repo Market Participants and Cash/Collateral Flows

Each arrow represents the direction of cash in a repo agreement; this means collateral moves in the opposite direction. Tri-party repo is denoted by two purple arrows both pointing to the left, passing through the rectangle representing the two tri-party custodians. Cash funding is provided from the investors in the right-most box to the broker-dealers in the center of the figure, in exchange for collateral. Tri-party repo is the largest of three repo markets and a primary cash source for the other two.

General Collateral Finance (GCF) repo is denoted by the two red dotted lines in the middle of the figure that curve and point counterclockwise. This market is inter-dealer and backed only by high-quality collateral: Treasuries, agency mortgage-backed securities, and agency debentures. GCF repo provides funding from one dealer to another, similar to the fed funds market for banks.

Bilateral repo is shown by the solid green arrows on the left half of the figure. The bilateral repo arrows point in both directions because broker-dealers both borrow from and lend to the various institutions shown in the oval on the far left.

Source: OFR analysis

rather than specific securities, which can be pledged as collateral. GCF repos are unique in that they have no haircut margin. The cash borrower can continue to use his or her securities freely to make markets and clear trades that day until 11 a.m., when the cash borrower must identify the specific securities it will actually deliver to the cash lender. GCF repo was designed to improve inter-dealer liquidity by netting obligations through the FICC and giving dealers flexibility to substitute collateral throughout the day as their portfolio changes. In 2012 the GCF repo market's total (pre-netting) average daily volume was $400 billion. However, since then the market has shrunk considerably, to only $210 billion per day in June 2014.[7]

2.3 Tri-party Repo Market

The tri-party repo market gets its name from the manner in which transactions are cleared. Tri-party repo counterparties transact through one of two custodian banks: Bank of New York Mellon and JPMorgan Chase. These two custodians provide tools to value collateral and apply haircuts for cash lenders, and help cash borrowers allocate their portfolio across lenders to achieve the lowest cost of financing. Collateral is moved from a cash borrower's account with the custodian to the cash lender's account with the custodian in exchange for cash at the start of a repo, and the transaction is reversed the next morning when the repo is unwound.[8]

The tri-party repo market finances approximately $1.7 trillion of collateral each day. There are 14 broad classes of collateral accepted, but over 80% of repos are backed by the most liquid assets: U.S. Treasuries or agency-backed securities. There are 63 different dealers, who get their cash funding from 170 different cash lenders (aggregating all subsidiaries to the parent level). Most cash lenders are either money market mutual funds (MMMFs), or

[7]Source: DTCC: http://www.dtcc.com/charts/dtcc-gcf-repo-index.aspx .

[8]In a term repo, this daily unwind still occurs, meaning the custodian extends an intraday loan to the cash borrower until the term repo is rewound in the afternoon. The Tri-Party Repo Infrastructure Reform Task Force has identified this intraday lending as a significant risk, and the two custodians have committed to developing a new settlement regime by the end of 2014 that is much less dependent on intraday credit provision (http://www.newyorkfed.org/newsevents/statements/2014/0213_2014.html .)

securities lending agents, but insurance companies, corporations, municipalities, commercial banks, and central banks also participate.[9] Money market funds can invest cash across a variety of high quality short-term investments such as commercial paper, bankers' acceptances, Treasury bills, variable rate demand notes, and repos. Because repos are fully collateralized with a haircut margin, they are a useful way for cash investors to limit their overall counterparty exposure to a dealer.[10]

As part of the custodian-investor relationship, cash lenders submit a custodial agreement that includes a schedule of haircuts to apply to the value of collateral pledged by each dealer in each asset class. The custodian will follow that agreement and can mark collateral to market and apply the haircut on the investor's behalf. The haircut may vary across asset classes (e.g., haircuts on riskier collateral such as corporate bonds or equities are typically above 5%, while haircuts on safer assets like U.S. Treasuries or agency securities may be as low as 1% or 2%), and may also vary by a cash lender's dealer counterparties.

Once set, haircut schedules are very inflexible. Anecdotally, when I asked cash lender repo participants and regulators to describe how haircuts are determined, they *all* responded that it is very burdensome to change the haircut: it takes around a dozen signatures up and down the firm to amend the haircut schedule, and money funds may also have to announce the change to their investors. If a cash lender decides a certain borrower or type of collateral is too risky, they will increase the repo rate they charge or reduce the quantity they lend, instead of adjusting haircuts. This is consistent with the findings of Krishnamurthy, Nagel, and Orlov (2014), who noted during the 2008 financial crisis that the tri-party repo market did not see a haircut spiral like Gorton and Metrick (2009, 2012) described in bilateral repo.

Part of the custodian's services to dealers is that they assist in the collateral allocation process. This means that each day the custodian bank will allocate a cash borrower's portfolio to whichever lenders are cheapest for that collateral. If a cash supplier tightens

[9] I determine this using supplementary tri-party repo data on cash lenders from January 2011, to July 2014.

[10] For example, other counterparty exposure could arise through holding that dealer's commercial paper.

lending, then its cash borrowers can move to the next cheapest source of financing (taking into account both the changing interest rate and the stable haircut).

3 Data

Table 1.
Summary of Data Sources

Market	**Data Source**	**Frequency, Granularity** of **Data**	**Description**
Tri-Party Repo	Federal Reserve Board of Governors	Daily, by Dealer & Collateral Type	Daily Summaries of Tri-Party Repo Transactions
Bank Holding Companies	Bankscope	Quarterly, for each Bank Holding Company	Balance Sheet Information
Money Market Mutual Funds	iMoneyNet	Daily, by Each Fund	Money Market Funds' Assets Under Management
Money Market Mutual Funds	SEC Form N-MFP (since Nov 2010)	Monthly, by Each Fund	Complete Money Market Fund Portfolio
Agency Bonds	FINRA TRACE (via WRDS) (since March 2010)	Intra-Day Transactions, CUSIP-level, with Counterparty Type	Agency Bond Market Dealer-Reported Transactions

Source: OFR analysis

Triparty Repo Data:

Tri-party repo market daily transaction summaries are obtained through the Office of Financial Research and the Federal Reserve Bank of New York, who in turn receive the data as reports from the two tri-party custodians, Bank of New York Mellon and JPMorgan Chase. The data in this sample begins July 1, 2008, and the sample ends July 31, 2014. The data includes the daily amount of cash borrowings for each dealer by each collateral asset

class, as well as the market value including interest due at the end of the repo. The ratio of those two quantities gives a measure of the dealer's overall cost of borrowing in that asset class (haircut plus interest, aggregated across all the dealer's counterparties).

I omit July 17, 2008, and April 11, 2013 from the sample, because on those two days I am missing data from one of the custodian banks. I also omit repos in which the Federal Reserve Bank of New York is a cash borrower from the sample, because of its role as a regulator, which causes it to behave very differently from other repo participants.[11]

The total average daily size of the tri-party repo market is $1.7 trillion during the sample period, and the majority of tri-party repo is backed by high-quality assets. The two largest asset classes are agency mortgage-backed securities and U.S. Treasuries and strips, which together comprise 69% of collateral pledged, followed by agency debentures and agency collateralized mortgage obligations (CMOs) (another 15% of the market). Table 2 provides summary statistics for the sizes of each asset class.

iMoneyNet, N-MFP

Money market mutual funds are a primary cash lender in the tri-party repo markets, so I use two separate datasets to observe how their portfolio changes at the end of each quarter.

iMoneyNet tracks the performance and portfolio composition of more than 1,600 U.S. money market funds and reports each money market fund's daily assets under management (AUM) as well as the type of fund (prime, government, or municipal).

In 2010 the SEC implemented reforms to the money market fund industry to reduce risk and improve disclosure. As part of that reform, money market funds have reported their detailed portfolio holdings every month since November 2010 in form N-MFP. These filings become public 60 days after filing, and the last filing I use is June 2014.

Bankscope

Bankscope reports data on the quarterly balance sheets of U.S. and international banks. I specifically use the balance sheets of banks whose dealers borrow in the tri-party repo

[11] See subsection 6.2 for an example of this.

Table 2.
Summary Statistics for the Tri-Party Repo Market

This table shows summary statistics for the size and composition of assets pledged as collateral in the tri-party repo market from July 1, 2008, to July 31, 2014.

Asset Class		Average Daily Repo $ Volume		Standard Deviation of Daily Repo $ Volume
Agency CMOs	$	**103,194,451,024**	$	**22,553,502,217**
Agency Debenture	$	**149,569,102,420**	$	**64,636,803,823**
Agency MBS	$	**616,533,453,994**	$	**114,945,935,282**
U.S. Treasuries and Strips	$	**569,974,504,613**	$	**71,111,887,693**
Total Fed-Eligible Collateral	$	**1,439,271,512,051**	$	**163,851,945,388**
Asset Backed Securities	$	40,386,045,329	$	7,718,426,654
Cash	$	671,831,740	$	1,476,710,744
Corporate Bonds	$	90,942,450,339	$	27,226,322,099
DTC-Other	$	1,612,224,985	$	1,847,938,550
Equity	$	90,418,652,876	$	26,316,780,190
Money Market	$	25,232,797,297	$	9,090,884,810
Municipal Bonds	$	14,670,908,771	$	4,249,596,754
Other	$	2,721,950,275	$	1,704,534,903
Private Label CMO	$	40,721,757,360	$	14,305,285,726
Whole Loans	$	5,103,289,663	$	6,327,712,831
Total Non-Fed-Eligible Collateral	$	312,481,908,635	$	63,887,940,704
Total	*$*	*1,751,753,420,686*	*$*	*194,858,199,512*

Source: Federal Reserve Board of Governors

market from June 2008 to June 2014, to match the time series of the repo data I have. Some Japanese banks' balance sheets are incomplete or unavailable in Bankscope, and this makes it difficult to empirically analyze the effect of a bank's balance sheet on repo behavior for bank dealers from Japan. For that reason I consider Japanese banks separately from European banks when I look at non-U.S. bank dealer activity in repo. For the U.S. and Europe, I do not run into issues with sample size or statistical power.

TRACE

The SEC mandates that broker-dealers report their transactions in eligible fixed-income securities. The Financial Industry Regulatory Authority collects these transactions through the Trade Reporting and Compliance Engine (TRACE), and makes a nonconfidential version

of this content available to researchers through Wharton Research Data Services (WRDS), which I use. Each transaction report identifies the dealer's counterparty as either another dealer or a customer, and the report details the security identifier (CUSIP), price, quantity, and direction of the trade. TRACE reports this data by the type of security, which in WRDS can be corporate bonds or agency bonds. I use the TRACE agency dataset, which begins in March 2010 and continues through June 2014.

4 Empirical Results

4.1 Repo Declines Significantly at Quarter-End

The decline in repo is visually apparent and statistically very pronounced. Panel A of Table 3 reports a regression of aggregate repo borrowing in the entire market and by the region of bank dealers, using indicator variables for each of the five days preceding and following the end of a quarter. Because the size of the repo market varies over time, I include fixed effects for each quarter. Column (4) of Table 3 shows that in aggregate, quarter-end repo is $169.4 billion below typical levels. However, on the first day of the quarter, repo strongly rebounds and continues to pick up over the next five days. Panel (B) repeats this analysis, but adds one-day lagged repo borrowing to account for auto-regression in the data and highlight the rebound in repo borrowing around the change of a quarter. Columns (2) and (3) of both Panels (A) and (B) show that this decline and rebound are strongly present in European and Japanese bank dealers as well. Even though their normal repo borrowing is comparable to European bank dealers, the U.S. decline in column (1) is an order of magnitude smaller and largely insignificant. This partially explains why previous studies using U.S. bank holding company Y-9C statements (such as Owens and Wu (2012) and Downing (2012)) fail to find seasonality or window dressing in the repo market: of all bank dealers, those of the U.S. do it the least.

European and Japanese bank dealers reduce their cash borrowing at quarter-end, and

Table 3.
Quarter-End Changes in Repo by Region

In columns (1) to (3) the dependent variable is the total daily market value of collateral pledged in U.S. tri-party repo by all bank dealers whose parent company is headquartered in a given region, which can be the U.S., Europe, or Japan. Column (4) instead uses the daily aggregate market value of collateral pledged by all dealers (bank as well as non-bank) in the entire U.S. tri-party repo market, regardless of dealers' home countries. In Panel A, the regressors are indicator variables for each of the five business days preceding and following a change in calendar quarter, as well as the last and first business day of a month that isn't the end or start of a quarter. In Panel B, the specification is the same except I add the auto-regressive term $Repo\ Borrowing_{region,\,t-1}$, as suggested by an AIC test. Estimation is based on OLS regression with time-fixed effects for each quarter in the sample period. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Indicator Variables for Time-of-Quarter

Total Repo Borrowing by Region ($ Billions)	(1) U.S. Bank Dealers	(2) European Bank Dealers	(3) Japanese Bank Dealers	(4) Aggregate Repo Borrowing
Fifth-to-Last Day of a Quarter	-8.729	-47.74***	-4.178***	-62.60***
	(8.790)	(10.40)	(1.111)	(11.49)
Fourth-to-Last Day of a Quarter	-9.343	-57.50***	-5.162***	-72.82***
	(9.113)	(10.03)	(1.243)	(10.70)
Third-to-Last Day of a Quarter	-10.83	-72.29***	-6.838***	-90.40***
	(9.459)	(9.642)	(1.353)	(11.10)
Second-to-Last Day of a Quarter	-16.82*	-96.53***	-7.609***	-119.1***
	(9.620)	(10.09)	(1.398)	(13.57)
Last Day of a Quarter	**-11.15**	**-150.9*** **	**-8.802*** **	**-169.4*** **
	(13.10)	(12.25)	(1.298)	(19.71)
First Day of a Quarter	7.011	-62.12***	-4.700***	-55.35***
	(7.848)	(9.520)	(0.832)	(14.53)
Second Day of a Quarter	5.397	-48.04***	-3.245***	-43.20***
	(7.420)	(8.421)	(0.535)	(12.66)
Third Day of a Quarter	4.172	-42.98***	-2.711***	-38.94***
	(6.963)	(8.804)	(0.523)	(12.30)
Fourth Day of a Quarter	1.747	-36.18***	-2.294***	-35.30***
	(7.107)	(7.519)	(0.466)	(11.06)
Fifth Day of a Quarter	3.868	-33.99***	-2.031***	-30.87***
	(6.827)	(6.157)	(0.477)	(9.892)
Last Day of a Month That Isn't a	7.183*	0.0272	0.0349	7.049*
Quarter-End	(3.819)	(2.233)	(0.318)	(4.098)
First Day of a Month That	2.340	13.02***	0.388	16.09***
Isn't the First Day of a Quarter	(2.629)	(1.377)	(0.323)	(3.296)
Constant	724.9***	855.7***	43.04***	1,749***
	(0.661)	(0.795)	(0.111)	(1.080)
Observations	1,522	1,522	1,522	1,522
R-squared	0.018	0.414	0.323	0.342

Source: Federal Reserve Board of Governors

(continued)

Panel B: AR(1) Term Added to Estimation

Total Repo Borrowing by Region ($ Billions)	(1) U.S. Bank Dealers	(2) European Dealers	(3) Japanese Bank Dealers	(4) Aggregate Repo Borrowing
Yesterday's Repo Borrowing	0.873***	0.902***	0.893***	0.878***
	(0.0352)	(0.0308)	(0.0275)	(0.0288)
Fifth-to-Last Day of a Quarter	-3.832*	-15.16***	-1.049**	-20.20***
	(2.128)	(2.535)	(0.485)	(3.890)
Fourth-to-Last Day of a Quarter	-1.519	-14.04***	-1.401***	-17.10***
	(2.259)	(2.627)	(0.413)	(3.479)
Third-to-Last Day of a Quarter	-2.470	-20.02***	-2.198***	-25.70***
	(2.530)	(2.314)	(0.345)	(3.154)
Second-to-Last Day of a Quarter	-7.160***	-30.91***	-1.472***	-38.95***
	(2.529)	(4.849)	(0.364)	(5.183)
Last Day of a Quarter	**3.735**	**-63.38*** **	**-1.977*** **	**-64.12*** **
	(6.196)	(5.897)	(0.454)	(11.75)
First Day of a Quarter	**0.949**	**55.18*** **	**4.070*** **	**59.86*** **
	(6.305)	(6.243)	(0.738)	(10.76)
Second Day of a Quarter	-0.399	8.432***	0.988**	6.170
	(2.436)	(2.584)	(0.401)	(4.012)
Third Day of a Quarter	-0.215	0.795	0.222	-0.238
	(1.789)	(3.138)	(0.301)	(2.694)
Fourth Day of a Quarter	-1.571	3.024	0.163	-0.325
	(1.808)	(1.989)	(0.308)	(3.483)
Fifth Day of a Quarter	2.666	-0.920	0.0531	0.899
	(2.474)	(1.913)	(0.248)	(3.374)
Last Day of a Month That Isn't a Quarter-End	6.587***	-1.018	-0.139	5.681
	(1.970)	(2.411)	(0.222)	(3.577)
First Day of a Month That Isn't the First Day of a Quarter	-3.725	13.38***	0.386**	10.69***
	(2.901)	(1.931)	(0.168)	(3.805)
Constant	91.93***	83.18***	4.569***	213.3***
	(25.53)	(26.30)	(1.193)	(50.43)
Observations	1,522	1,522	1,522	1,522
R-squared	0.762	0.899	0.855	0.861

Source: Federal Reserve Board of Governors

they do this consistently across the entire sample. Table 5 reports just quarter-end indicators for each quarter in our sample (2008 Q3 to 2014 Q2). For Europe and Japan, bank dealers reduce their repo borrowing every single quarter. U.S. bank dealers don't follow a consistent pattern. Sometimes they reduce their repo, but just as often their repo borrowing will increase at the quarter-end.

Just as the decline in repo is concentrated in non-U.S. borrowers, the decline is happening only in safer collateral, which is more liquid and easier to sell and then buy back for window dressing purposes. Window dressing by selling the riskier, less liquid assets would be costlier, and its effect on required ratios such as the net stable funding ratio is very similar. Table 6 reports quarter-end declines separately for safe collateral—defined as U.S. Treasuries, agency MBS and agency debentures, and money market collateral—and for all other types of collateral. Safer collateral is $148 billion below normal at the quarter-end, when accounting for quarterly fixed effects. Riskier collateral declines by only $13 billion, so per dollar invested the repo market actually becomes riskier at quarter-end.

4.2 Alternative Explanation: Seasonal Effects in Cash Supply

A simple explanation for the decline in tri-party repo could be that cash lenders hoard liquidity at the end of the quarter for their own purposes. Money market mutual funds are one of the primary lenders in the tri-party repo market, and they could cut their lending to meet outflows by their own investors at the end of the quarter. Those investors in turn could need cash to settle obligations like dividend payouts, taxes, settlement on derivatives, or debt payments. In other words, knowing only the quantity of repo, I would not be able to identify whether repo demand effects or repo supply effects are driving the quarter-end decline. Data from both iMoneyNet and the recently-created form N-MFP filings (starting in November 2010) show that cash supply phenomena are not causing the drop in repo.

Using daily data on from iMoneyNet, I apply the same specification I used in Panel B of Table 3 except I use money funds' assets under management (AUM) as the dependent

Table 5.
Quarter-End Drops In Repo Borrowing Over Time

In columns (1) to (3) the dependent variable is the total daily market value of collateral pledged in U.S. tri-party repo by all bank dealers whose parent company is headquartered in a given region, which can be the U.S., Europe, or Japan. Column (4) instead uses the daily aggregate market value of collateral pledged by all dealers (bank as well as non-bank) in the entire U.S. tri-party repo market, regardless of dealers' home countries. The regressors are indicator variables for the last business day of each quarter in the sample, to indicate how the size of the quarter-end decline in repo borrowing changes over time. Estimation is based on OLS regression with time-fixed effects for each quarter in the sample period. Heteroskedasticity-robust standard errors are used to determine significance, but not reported separately due to space constraints. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Total Repo Borrowing by Region ($ Billions) Quarter & Year Fixed Effects	(1) U.S. Bank Dealers	(2) European Bank Dealers	(3) Japanese Bank Dealers	(4) Aggregate Repo Borrowing
2008Q3	128.4***	-84.31***	-5.384***	-111.5***
2008Q4	13.14***	-331.8***	-1.597***	-333.0***
2009Q1	-105.5***	-171.0***	-7.679***	-281.9***
2009Q2	-164.6***	-197.3***	-0.527***	-363.0***
2009Q3	-75.09***	-144.9***	-1.900***	-227.4***
2009Q4	-86.09***	-202.6***	2.045***	-290.2***
2010Q1	-81.13***	-168.0***	-2.404***	-261.0***
2010Q2	-48.41***	-110.2***	-0.0172***	-176.3***
2010Q3	-40.29***	-147.9***	-0.938***	-157.0***
2010Q4	-6.341***	-228.8***	-5.102***	-254.7***
2011Q1	-0.345***	-165.8***	-12.82***	-163.4***
2011Q2	8.424***	-118.6***	-13.91***	-104.7***
2011Q3	49.85***	-105.7***	-13.90***	-45.76***
2011Q4	15.22***	-74.31***	-6.012***	-68.86***
2012Q1	6.913***	-94.08***	-13.10***	-92.32***
2012Q2	53.53***	-122.0***	-8.168***	-48.36***
2012Q3	58.51***	-135.9***	-10.16***	-67.75***
2012Q4	27.16***	-169.8***	-13.99***	-143.9***
2013Q1	-47.02***	-114.6***	-16.13***	-157.6***
2013Q2	6.149***	-144.5***	-15.06***	-142.3***
2013Q3	17.08***	-72.09***	-12.04***	-48.12***
2013Q4	13.55***	-145.7***	-16.76***	-148.1***
2014Q1	-31.54***	-78.52***	-14.10***	-112.8***
2014Q2	24.41***	-105.0***	-6.993***	-71.09***
Constant	725.0***	848.1***	42.38***	1,742***
Observations	1,530	1,530	1,530	1,530
R-squared	0.076	0.199	0.132	0.185

Source: Federal Reserve Board of Governors

Table 6.
Declines in Quarter-End Repo Borrowing by Type of Collateral

In Column (1) the dependent variable is the total daily market value of **fed-eligible collateral** pledged in U.S. tri-party repo by all dealers. In Column (2) the dependent variable is the total daily market value of **non-fed-eligible collateral** pledged in U.S. tri-party repo by all dealers. Regressors are indicator variables for the last and first business days of a quarter and the last and first business days of a month that isn't the end or start of a quarter. Estimation is based on OLS regression with time-fixed effects for each quarter in the sample period. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Total Repo Borrowing by Collateral Type ($ Billions)	(1) Fed-Eligible Collateral	(2) non-Fed-Eligible Collateral
Last Day of a Quarter	-147.8***	-12.92***
	(17.90)	(4.384)
First Day of a Quarter	-47.81***	1.082
	(11.72)	(6.262)
Last Day of a Month That Isn't a	14.94***	0.710
Quarter-End	(4.185)	(0.986)
First Day of Month That Isn't the	23.87***	0.979
Start Of a Quarter	(3.501)	(1.003)
Constant	1,429***	312.1***
	(0.306)	(0.0533)
Observations	1,529	1,529
R-squared	0.155	0.012

Source: Federal Reserve Board of Governors

variable, rather than total tri-party repo market borrowing. Table 7 shows that money funds do see outflows at the end of the quarter followed by inflows at the start of the new quarter, but they are less than a tenth the size of repo declines. Additionally, there is no significant decline in MMFs' AUM before the last day of the quarter, unlike the accelerating drawdown over several days that happens in repo. Therefore, money fund outflows cannot explain the size and scope of the repo market effect.

Although money funds are one of the two primary types of cash lenders in tri-party repo, they are not the only tri-party cash provider. Securities lending agents also reinvest cash collateral in tri-party repo, so a regular and sudden quarter-end unwinding of securities lending could also pull cash out of the tri-party repo system. Although I do not have data on securities lending covering this period, I do have data on money market funds' detailed portfolio holdings from the new form N-MFP, which contradicts this account.

Since form N-MFP is a monthly, not quarterly, filing, I do not have to worry about money funds themselves window-dressing their quarter-end holdings any more than they would for a different month. Therefore, I can compare quarter-end holdings to holdings at the end of other months to see what changes. Table 8 shows that at the quarter-end, money funds' repo holdings decline, even though their AUM does not decline significantly. I do not report non-repo asset classes in the table because no other reported investment classes have significant quarter-end changes. However, I do report money market funds' *uninvested* cash, which is the remainder from subtracting the sum of all its investments from a fund's reported AUM.[12]

Table 9 reports that money funds are holding excess cash at the end of the quarter, both individually and in aggregate. Money market funds specialize in making short-term investments, but prime and government/agency MMFs together cannot find temporary investments for nearly $20 billion dollars,[13] meaning there is an excess—not a shortage—of

[12]Normally, a money fund will actually have a cash balance of zero or just slightly less than zero, with any shortfall due to the fact that a sponsor may have invested its own money in the fund to support it, which is not reflected in the fund's AUM.

[13]$12.62 billion for prime MMFs, $7.188 billion for govt/agency MMFs, see column (4) of Table 9.

Table 7.
Money Market Fund Changes in AUM around Quarter-End

The dependent variable is the total daily assets under management (AUM) of all U.S. money market mutual funds (MMFs) in millions of dollars, and excluding tax-free MMFs. Feeder funds are excluded from this amount. Data on the type of a fund and its AUM is obtained from iMoneyNet, and spans the time period from July 1, 2008, to February 13, 2014. Lagged total MMF AUM is included to account for auto-regression. In columns (1) and (2), indicator variables for the last day of a quarter, and the days surrounding a quarter-end and a month-end (that isn't a quarter-end) are included, respectively. In columns (3) and (4), I modify all of the indicator variables to only indicate those quarter- (month-) ends in which the last business day of that quarter (month) is also a Friday, to control for potential cash outflows to meet MMF investors' cash needs, such as for payroll. Estimation is based on OLS regression with time-fixed effects for each quarter in the sample period. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

(7/1/2008–2/13/2014) Total MMF AUM ($ millions, and excluding tax-free funds)	(1)	(2)	(3) Only Friday Quarter-ends	(4) Only Friday Quarter-ends
Yesterday's AUM	0.999***	1.000***	0.999***	1.000***
	(0.000840)	(0.000761)	(0.000856)	(0.000828)
Fifth-to-Last Day of a Quarter		5,125**		4,492
		(2,041)		(4,501)
Fourth-to-Last Day of a Quarter		1,981		4,689***
		(1,718)		(1,543)
Third-to-Last Day of a Quarter		1,790		-1,067
		(1,380)		(1,441)
Second-to-Last Day of a Quarter		-2,411		1,927
		(1,902)		(1,982)
Last day of a Quarter	**-12,447*** **	**-13,748*** **	**-14,078*** **	**-14,008*** **
	(2,425)	(2,625)	(2,392)	(2,404)
First day of a Quarter		1,003		-5,855**
		(2,603)		(2,689)
Second day of a Quarter		9,053***		6,495***
		(2,043)		(1,437)
Third day of a Quarter		3,926***		4,567**
		(1,251)		(2,280)
Fourth day of a Quarter		2,930**		537.4
		(1,299)		(2,630)
Fifth day of a Quarter		2,495*		-1,078
		(1,372)		(1,962)
Second-to-Last Day of a Month That Isn't a Quarter-End		298.7		3,018*
		(1,390)		(1,593)
Last Day of a Month That Isn't a Quarter-End		-12,553***		-13,322***
		(1,635)		(2,673)
First Day of a Month that Isn't the Start of a Quarter		-2,197		-5,128*
		(1,781)		(2,749)
Second Day of a Month that Isn't the Start of a Quarter		9,600***		11,223***
		(846.1)		(1,206)
Constant	1,409	172.1	1,652	819.0
	(2,098)	(1,896)	(2,138)	(2,061)
Observations	1,405	1,526	1,405	1,526
R-squared	0.999	0.999	0.999	0.999

Source: iMoneyNet

Table 8.
MMF Repo Cash Lending at the End of the Quarter

In Panels A and B, column (1), the dependent variable is the assets under management (AUM) of an individual prime or government/agency money market mutual fund (MMF), respectively, in millions of dollars. In column (2), the dependent variable is the total market value of repo cash lending by an individual MMF that is backed by agency securities as collateral. In column (3), the dependent variable is the same as in column (2), except receiving Treasury securities as collateral, and in column (4), it is repo backed by all other types of collateral. In Panel C, I change the dependent variables to the total aggregate AUM or repo lending across the entire MMF industry, and change the units to billions of dollars. The data is obtained from monthly form N-MFP filings, the sample in this regression is November 2011 to July 2013. The regressor is an indicator variable for the date being the last month of the quarter. Estimation is done by OLS regression. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Prime MMFs	(1)	(2)	(3)	(4)
($ Million)	Total Assets	Agency Repo	Treasury Repo	Other Repo
Last Month	-21.72	-192.7***	-142.4***	4.769
of Quarter	(426.5)	(63.09)	(37.29)	(131.9)
Constant	6,999***	1,052***	504.0***	1,211***
	(251.1)	(40.30)	(27.95)	(75.71)
Observations	6,313	3,979	2,779	1,791
R-squared	0.000	0.002	0.004	0.000
Panel B: Govt/Agency MMFs				
($ Million)	Total Assets	Agency Repo	Treasury Repo	Other Repo
Last Month	115.1	-22.77	-185.0**	112.8
of Quarter	(380.6)	(232.0)	(73.44)	(316.3)
Constant	4,817***	2,233***	805.7***	560.3***
	(220.0)	(135.5)	(51.63)	(193.1)
Observations	2,653	1,704	1,389	119
R-squared	0.000	0.000	0.004	0.001
Panel C: Total MMF Industry				
($ Billion)	Total Industry AUM	Agency Repo	Treasury Repo	Other Repo
Last Month	-22.80	-35.83***	-25.64***	-1.384
of Quarter	(19.92)	(10.96)	(6.173)	(5.685)
Constant	2,214***	307.5***	96.06***	84.28***
	(12.90)	(7.650)	(4.087)	(3.258)
Observations	32	32	32	32
R-squared	0.038	0.229	0.337	0.002

Source: SEC Form N-MFP

cash supply at quarter-end. If securities lenders or other unobserved tri-party repo cash suppliers were choosing to cut their repo lending and dealers' demand for repo was unchanged, dealers would have been able substitute and borrow cash from money market funds instead, and money market funds would not have this excess cash.

4.3 Dealer Leverage Explains Non-U.S. Bank Dealer Repo Quarter-End Declines

Earlier tests in this paper showed no evidence to support a cash supply-driven effect, but here I do find evidence consistent with a cash demand-driven effect. Among the differences across capital regulation regimes in the U.S., Europe, and Japan, the most relevant aspect for this study is the reporting requirement. U.S. banks are required to report capital ratios for the last day of the quarter as well as an average across all days of the quarter. In contrast, non-U.S. banks can simply report for the last day of the quarter. Therefore, U.S. banks have very little incentive to window-dress their balance sheet at the end of the quarter—it will not affect their capital requirements any more than a deviation any other time in the quarter would. If this is indeed what's driving the difference I observe between U.S. and non-U.S. bank dealers, I would expect more levered non-U.S. bank dealers to be more likely to window-dress.

I link the tri-party repo holdings for each bank dealer to that bank's quarterly balance sheet, using data obtained from BankScope. One limitation of BankScope is that it does not contain data on all banks, especially Japanese banks. However, for the U.S. and Europe, I am able to link almost all dealers to their banks. In Table 10, I test a fixed-effects regression model for each region, where I supplement my end-of-quarter indicator variables with the linked bank balance sheet for the previous quarter. To specifically test whether highly levered banks are reducing their dealers' repo borrowing at the end of the quarter to report lower leverage, I interact the bank's Tier 1 capital ratio from the previous quarter with an indicator for the last day of the current quarter. A higher Tier 1 capital ratio means less leverage, so

Table 9.
MMF Cash Surplus at the End of the Quarter

In columns (1) and (2), the dependent variables are the percent of an individual money market mutual fund's (MMF's) assets under management (AUM) that is held in uninvested cash at the end of the month, and the value of an individual MMF's uninvested cash in millions of dollars, respectively. Uninvested cash is calculated as the remainder of an MMF's AUM after subtracting the value of all securities in an MMF's portfolio. In columns (3) and (4), the dependent variables are aggregate AUM at the end of the month and aggregate uninvested cash holdings at the end of the month, respectively, for all MMFs in an industry classification (prime or govt/agency). Both (3) and (4) report in billions of dollars. Panel A reports results among all prime MMFs, and Panel B repeats the exercise for all government/agency MMFs. The data is obtained from monthly form N-MFP filings; the sample in this regression is November 2011 to July 2013. The regressor is an indicator variable for the date being the last month of the quarter. Estimation is done by OLS regression. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A: Prime MMFs

	(1) % of AUM Held as Cash	(2) Cash Holdings ($ Millions)	(3) Aggregate AUM ($ Billions)	(4) Aggregate Cash Holdings ($ Billions)
Last Month of	0.00534***	51.96***	-10.34	12.62***
Quarter	(0.00191)	(8.805)	(24.92)	(3.941)
Constant	0.00217*	-38.69***	1,701***	-9.403***
	(0.00111)	(4.498)	(15.73)	(2.676)
Observations	6,339	6,313	26	26
R-squared	0.001	0.006	0.007	0.270

Panel B: Govt/Agency MMFs

	% of AUM Held as Cash	Cash Holdings ($ Millions)	Aggregate AUM ($ Billions)	Aggregate Cash Holdings ($ Billions)
Last Month of	0.0101***	70.48***	10.63	7.188***
Quarter	(0.00283)	(12.53)	(9.045)	(1.831)
Constant	-0.00116	-33.89***	491.9***	-3.461***
	(0.00154)	(5.744)	(5.070)	(.8366)
Observations	2,659	2,653	26	26
R-squared	0.005	0.014	0.057	0.441

Source: SEC Form N-MFP

if window dressing is driving repo declines, this regression coefficient must be positive. The first row of column (3) shows that for European bank dealers, this coefficient is positive and significant, suggesting window dressing incentives do explain their repo borrowing. Moreover, the same coefficient for U.S. bank dealers in column (2) is insignificant and actually negative, just as we would expect given their quarter-average reporting requirement. Therefore, this cross-region test seems to confirm that the difference between U.S. and European bank dealer behavior is explained by window dressing.

4.4 Joint Model Test

Thus far, in looking at cash suppliers and cash demanders separately, evidence rejects a supply shift and favors a demand shift. However, to confirm this result, I use a proxy for the price of repo borrowing (the sum of the haircut and the repo rate) in each asset class. With this dealer-specific measure of the price of repo, I can test both quantity and price at the end of the quarter, to determine whether the dominant effect is from cash demand or supply.

Because the cost of borrowing in repo is dealer-specific as well as asset class-specific, I test quarter-end effects in quantity and price of repo by each dealer, in each of their collateral types. I control for variation between dealers and between asset types by adding fixed effects for each quarter, dealer, and asset class in Table 11. Column (4) shows that while non-U.S. bank dealers do less repo at the end of the quarter, the cost to borrow does not rise at all—in fact, the coefficient is slightly negative.[14]

4.5 Identification Using the Dealer-Lender Network

One limitation of my analysis so far is that it still suffers from the potential for omitted variable bias. Non-U.S. bank dealers may be borrowing from a different set of lenders than

[14]In contrast, U.S. bank dealers do not window-dress, and their borrowing cost even rises slightly (and there is no reversal at the start of the new quarter).

Table 10.
Repo Borrowing by a Dealer

The dependent variable is the daily market value of collateral pledged in repo by an individual dealer. In column (1), the sample includes all dealers in U.S. tri-party repo, in columns (2) to (4), I reduce the sample to dealer subsidiaries of U.S. banks, European banks, and Japanese banks, respectively. Regressors include end-of-quarter reported Tier 1 capital ratio (as percent, not decimal, i.e., 12 not .12), and the total value in billions of dollars of derivatives and of total assets for the dealer's parent bank the prior quarter. These regressors are also interacted with an indicator variable for the last day of the current quarter ("Quarter-end"). I also include time dummies for the days preceding a quarter- or month-end, as well as the days following a new quarter; however, they are not reported due to page constraints but available upon request. Quarterly balance sheet data is obtained from Bankscope and covers most U.S. and European banks. However, it does not cover enough Japanese banks to report the full empirical specification in column (4). Estimation is based on OLS regression with time-fixed effects for each quarter in the sample period. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Repo Borrowing by a Dealer ($ Millions)	(1) All Dealers	(2) U.S. Bank Dealers	(3) European Bank Dealers	(4) Japanese Bank Dealers
Quarter-end x Tier 1 Ratio	682.0***	-852.2	**755.1****	-504.9
	(264.7)	(667.9)	(323.7)	(353.5)
Quarter-end x Derivatives	-13.44***	191.6***	-8.061***	-19.58
Outstanding($ Billions)	(2.803)	(70.40)	(2.892)	(27.89)
Quarter-end x Total Assets	0.602	-3.068**	-0.659	3.990*
($ Billions)	(0.560)	(1.491)	(1.114)	(2.217)
Tier 1 Ratio	15.96	70.27**	8.748	–
	(15.01)	(32.02)	(21.57)	
Total Quarter-End Dealer	0.219*	1.790	0.233	–
Derivatives Outstanding($ Billions)	(0.132)	(3.643)	(0.142)	
Total Quarter-End Assets	0.0821**	0.104	0.125***	–
($ Billions)	(0.0367)	(0.102)	(0.0442)	
1-Day Lagged Repo	0.997***	0.996***	0.996***	0.927***
Borrowing ($ Millions)	(0.000709)	(0.00101)	(0.00120)	(0.0156)
Last Day of a Quarter	-8,462***	10,844	-10,315**	-2,021
	(3,072)	(8,571)	(4,110)	(3,679)
First Day of a Quarter	2,745***	-1,978***	5,971***	4,102***
	(477.9)	(699.2)	(867.3)	(694.9)
Last Day of a Month That Isn't	339.6	1,189***	-112.2	-235.0
a Quarter-End	(237.1)	(227.7)	(326.6)	(200.1)
Constant	-168.9	-879.7**	-114.9	2,486***
	(178.1)	(440.0)	(227.8)	(552.7)
Observations	22,256	7,308	11,781	1,251
R-squared	0.996	0.997	0.995	0.885

Source: BankScope and Federal Reserve Board of Governors

Table 11.
Estimating Repo Quantity and Price Separately

In columns (1) and (3), the dependent variable is the daily market value of collateral pledged in repo by a single dealer, using a single class of collateral, in millions of dollars. In columns (2) and (4), the dependent variable is the daily cost of borrowing, which I calculate as the ratio minus 1 of the market value of collateral pledged in repo by a single dealer, using a single class of collateral, over the value of cash received in repo by that dealer using that collateral, times 100. The regressors include the cost of borrowing and the prior day's total market value of collateral pledged in repo by that dealer using that collateral for columns (1) and (3), and in columns (2) and (4), they instead include the prior day's cost of borrowing and the current day's total market vlaue of collateral pledged in repo by that dealer using that collateral type. Regressors also include indicator variables for the 5 business days before and after the turn of a quarter, as well as the day before and after the start of a month that isn't the end or start of a quarter. I do not report results for the indicators 2–5 days around the turn of a quarter; however, they are available upon request. Columns (1) and (2) use the sample of dealer subsidiaries of U.S. banks, and columns (3) and (4) use the sample of dealer subsidiaries of non-U.S. banks. Estimation is based on OLS regression with time-fixed effects for each quarter, dealer, and collateral asset class. Bootstrapped heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

(Fixed Effects by Each Quarter, Dealer & Asset Class)	(1) U.S. Bank Repo Borrowing ($ Millions)	(2) U.S. Bank Haircut (%)	(3) Non-U.S. Bank Repo Borrowing ($ Millions)	(4) Non-U.S. (%) Bank Haircut (%)
Haircut (%)	-24.80***		-13.46***	
	(3.186)		(2.444)	
Yesterday's Repo	0.963***		0.983***	
Borrowing ($ Millions)	(0.00410)		(0.00166)	
Repo Borrowing		-6.66e-06***		-3.35e-06***
($ Millions)		(1.39e-06)		(4.59e-07)
		(2.93e-06)		(7.71e-07)
Yesterday's Haircut		0.794***		0.931***
		(0.0445)		(0.00885)
Last Day of a Quarter	**70.66**	**0.0423***	**-527.0*** **	**-0.00871**
	(93.00)	(0.0247)	(67.75)	(0.0159)
First day of a Quarter	3.236	0.0502*	644.7***	-0.0121
	(72.58)	(0.0281)	(69.52)	(0.0128)
Last Day of a Month That	87.53***	0.00297	-13.46	-0.00846
Isn't a Quarter-End	(28.20)	(0.0207)	(27.05)	(0.00769)
First Day of a Month that	-56.06*	0.00853	136.2***	-0.0155
Isn't the Start of a Quarter	(29.54)	(0.0154)	(27.64)	(0.0102)
Constant	470.0***	1.05***	188.8***	0.305***
	(48.09)	(0.225)	(19.34)	(0.0385)
Observations	115,044	115,043	157,517	157,512
R-squared	0.927	0.636	0.968	0.875

Source: Federal Reserve Board of Governors

U.S. bank dealers, and those lenders may face different shocks at the end of the quarter. To control for any other potential cash lender effects, I use an additional data set on the network of tri-party repo lending since 2011. Similar to Khwaja and Mian (2008), I can use the network to examine the quarter-end effect within a cash lender using both lender and time-fixed effects. Table 12 reports that within a single lender, quarter-end repo borrowing by European bank dealers drops 13.6%, while U.S. and Japanese bank dealer borrowing is not significantly affected.

In a further test, I use a subset of the dealer-investor network that allows me to identify price effects in the haircut and the repo rate separately. Since November 2010, money market funds have published complete end-of-month portfolio holdings, including all repurchase transactions and the haircut and rate applied on the underlying collateral[15]. To fully identify price and quantity effects, I collect and use this data on the sub-network of tri-party repo transactions where money market funds are the cash investor. Table 13 shows that while money funds lend less to European dealers at quarter-end, repo rates drop at quarter-end for both U.S. and European bank borrowers and haircuts are not significantly affected for any participants. This drop in both quantity (for European banks) and in market price (via the repo rate) is consistent with a shock to cash demand rather than cash supply, which supports window dressing as the likely explanation for the quarter-end repo anomaly.

5 Robustness Tests

5.1 Unit Root

If repo borrowing follows a unit root process, this might lead to a problem of spurious regression. I test for unit roots in the quantity of repo borrowing using an Augmented Dickey-Fuller test allowing for drift in the series and find rejection of that hypothesis. Because I am

[15] A recent paper by Hu, Pan, and Wang (2014) uses this N-MFP filing data to conduct an extensive survey of tri-party repo pricing practices, and is the only other paper I am aware of which takes advantage of this pricing data.

Table 12. Within-Lender Variation in Repo Lending

The dependent variable is the natural log of the daily total market value of collateral pledged in repo by an individual dealer to an individual repo cash lender. The regressors are the natural log of the prior day's total market value of collateral pledged, as well as indicator variables for the last business day of a quarter and month, the country of origin of a dealer's parent bank, and the interaction of those terms. Estimation is based on OLS regression with lender-time-fixed effects for each quarter in the sample period, for each cash lender in the sample. Heteroskedasticity-robust standard errors clustered by lender are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) log(Total Repo)	(2) log(Total Repo)
Yesterday's log(Total Repo)	0.991***	0.991***
	(0.000386)	(0.000379)
Last Day of a Quarter	0.000184	0.000324
	(0.0324)	(0.0324)
Europe Quarter-End	**-0.136*** **	**-0.137*** **
	(0.0182)	(0.0182)
Japan Quarter-End	-0.0281	-0.0287
	(0.0185)	(0.0185)
U.S. Quarter-End	-0.00876	-0.00782
	(0.0157)	(0.0157)
Last Day of a Month That		-0.0668
Isn't a Quarter-End		(0.0463)
Europe Month-Not-Quarter-End		-0.0296***
		(0.0105)
Japan Month-Not-Quarter-End		-0.0219*
		(0.0130)
U.S. Month-Not-Quarter-End		0.0203*
		(0.0109)
Europe	0.00983***	0.0107***
	(0.00133)	(0.00134)
Japan	0.00365*	0.00427**
	(0.00204)	(0.00205)
U.S.	0.00749***	0.00665***
	(0.00133)	(0.00132)
Constant	0.183***	0.186***
	(0.00771)	(0.00744)
Observations	301,620	301,620
R-squared	0.984	0.984

Source: Federal Reserve Board of Governors

Table 13. Within-Investor Identification Using Pricing Data

In column (1), the dependent variable is the natural log of the total market value of collateral pledged in repo by an individual dealer to an individual money market fund on the last day of a month. In columns (2) and (3), the dependent variables are the average repo rate and haircut, respectively, charged to a dealer by a money market fund on the last day of a month. The regressors are indicators for the last day of a quarter, as well as the last day of a quarter interacted with indicators for whether the repo borrower belongs to a bank from the U.S., Europe, or Japan, respectively. Additionally, the natural log of a money market fund's assets under management (AUM) is added as a regressor, and in columns (1) to (3), a 1-period lag term of the dependent variable is also added. Estimation is based on OLS regression with lender-time-fixed effects for each quarter in the sample period, for each cash lender in the sample. Heteroskedasticity-robust standard errors clustered by lender are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
VARIABLES	ln(Repo Lending)	Repo Rate	Haircut
Quarter-End	-0.0594***	-0.0223***	0.0345
	(0.0228)	(0.00231)	(0.0239)
U.S.×Quarter-End	0.0305	-0.00627***	-0.0158
	(0.0280)	(0.00198)	(0.0197)
Europe×Quarter-End	-0.168***	-0.00574***	0.0299
	(0.0253)	(0.00175)	(0.0567)
Japan×Quarter-End	0.0267	0.0143***	-0.0180
	(0.0585)	(0.00390)	(0.0183)
Δ ln(AUM)	0.901***	-0.0212***	-0.0454
	(0.0590)	(0.00678)	(0.0439)
$\ln(\text{Repo Lending}_{t-1})$	0.651***		
	(0.0103)		
Repo Rate_{t-1}		0.847***	
		(0.0111)	
Haircut_{t-1}			0.672***
			(0.0217)
Constant	6.499***	0.0341***	0.0624***
	(0.191)	(0.00234)	(0.0130)
Observations	48,036	48,036	48,036
R-squared	0.427	0.743	0.411

Source: SEC Form N-MFP

also testing repo borrowing at the dealer level, I further test for unit roots across the panel using a Fisher-type Augmented Dickey-Fuller test, and again reject the null hypothesis that repo borrowing is a unit root process.

If repo borrowing is not a unit root process but is actually near unit root, my tests for a unit root would suffer from reduced power. Therefore, I also test for window dressing using changes in logs rather than an AR(1) specification. Again, I find a significant quarter-end drop and subsequent rebound in repo borrowing for non-U.S. banks, which is concentrated in highly levered banks and in repo backed by safe, liquid collateral.

5.2 Panel VAR

I chose to use simultaneous equations for my main empirical strategy because quarter-ends obviously arrive exogenously. However, to test the identification of my model of supply and demand, I used a vector auto-regression (VAR) approach. Because tri-party repo haircuts are dealer– and collateral-specific, I run a panel VAR at the dealer and asset-class level. Standard model selection technique (AIC) suggests I use 1-period lags. My panel VAR results are still consistent with window dressing: dealer leverage predicts significantly lower quarter-end repo borrowing, although I do not retain significance on other balance sheet measures.

5.3 U.S. Bank Holding Company Data

Other researchers have used data on U.S. bank holding companies (BHCs) to find evidence of window dressing by U.S. banks. This is inconsistent with my results using the tri-party repo data, in which I find that window dressing was concentrated in highly leveraged non-U.S. BHCs. The most compelling results are from Owens and Wu (2012), who use public reports filed by BHCs in form Y-9C. These reports include the quarter-average and quarter-end balance sheet data of these banks, and those authors take the discrepancy between those two measures as evidence of window dressing. To test their result, I repeat their analysis

using Y-9C data from 2001 through 2013, which I obtain through WRDS. Column (1) of Table 14 reports similar findings to their Table (4) Column (1): window dressing is indeed concentrated among BHCs with high leverage.

In Columns (2) and (3), I divide the sample into BHCs that are U.S.-based, and those bank holding companies that are subsidiaries of a non-U.S. parent.[16] The effect of leverage is entirely concentrated in the few non-U.S. BHCs, and the size effect is quite nearly captured by non-U.S. BHCs as well. Additions to loan loss reserves during the prior quarter are intended to account for non-window dressing pressures to de-leverage, and this effect remains for the U.S. BHCs but not the non-U.S. BHCs. These results are consistent with my findings in tri-party repo: non-U.S. bank holding companies window-dress and thereby improve the appearance of their parents' own financial statements.

6 Spillover Effects from Window Dressing

6.1 Agency Bond Markets

Repurchase agreements give cash in exchange for collateral, and when a dealer decides not to repo an asset, they must either find alternative financing or sell the asset. Repo window dressing is concentrated in safe assets: Treasuries, agency MBS and agency bonds, and money market assets (e.g., CDs). Since March 2010, the Financial Industry Regulatory Authority (FINRA) has collected data on all agency bond transactions involving dealers, and made them available to researchers through WRDS.[17] In this subsection, I use this data, including the price, quantity, time of execution and settlement, and direction (dealer-to-dealer or dealer buying/selling to a non-dealer) of each trade, to examine the impact of dealer window dressing on market quality for agency bonds.

[16] I also impose the same requirement as Owens and Wu (2012) that these bank holding companies have total consolidated assets greater than $500 million.

[17] I am unable to locate high-frequency data on Treasury transactions, and in a follow-up extension to this paper, I am currently processing data from FINRA's new TRACE dataset of agency MBS transactions, which are not included in this paper.

Table 14.
Quarterly Changes in Repo and Fed Funds Liabilities By Country

The dependent variable is the measure of window dressing of repo and fed funds liabilities proposed by Owens and Wu (2012) for an individual bank holding company (BHC). The regressors are also those proposed by the same paper. These are the prior quarter's average leverage for the BHC; the natural logarithm of quarterly average total assets; an indicator variable that = 1 if quarter t ended between 2007 Q4 and 2009 Q2, inclusive, and 0 otherwise; and the loan loss provision as a percentage of gross loans for the prior quarter. Column (1) estimates using the entire sample of BHCs that report in form Y-9C and have total assets greater than $500 million, columns (2) and (3) reduce that sample to those BHCs whose ultimate parent is either in the U.S. or not in the U.S., respectively. Estimation is based on OLS regression. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Owens & Wu (2012) Window Dressing Measure	(1) All BHCs	(2) U.S. BHCs	(3) non-U.S. BHCs
Quarter-Average Leverage$_{t-1}$	-3.92e-05***	-4.26e-06	-3.68e-05***
	(4.56e-06)	(7.97e-06)	(8.28e-06)
ln(Size)$_{t-1}$	-0.000829***	-0.000301*	-0.0110***
	(0.000160)	(0.000163)	(0.00137)
Crisis Period	0.000385	0.000492	-0.00533
	(0.000579)	(0.000576)	(0.00792)
LLR$_{t-1}$	-0.139***	-0.141***	0.0963
	(0.00865)	(0.00860)	(0.130)
Constant	0.0128***	0.00494**	0.169***
	(0.00230)	(0.00235)	(0.0229)
Observations	18,306	18,118	188
R-squared	0.019	0.015	0.369

Source: Federal Reserve Form Y-9C

When looking across markets, it's important to control for differences in the settlement process of each security. Repurchase agreements are "T+0" transactions, meaning that cash and securities are exchanged on the same day as the trade is executed. Agency bonds typically settle on "T+1," meaning the next business day after execution. If a dealer chooses not to finance his or her securities in repo anymore on a given day, he or she will still need to return cash to repurchase their securities that same day. Therefore, from the dealer's perspective, cash timing across markets is strategically important for window dressing. TRACE includes data on settlement as well, so to compare bonds and repo, I adjust each trade in Agency TRACE to the date of cash settlement. For the remainder of this paper, I will call the time of a trade the date of its settlement instead of its execution.

Table 15 shows that in the days preceding a quarter-end, dealers are on net, selling heavily to non-dealers (giving up assets for cash). However, once the new quarter starts, dealers are immediately relevering by buying back agency bonds. In the inter-dealer network, Column (2) reports that inter-dealer trading rises to three times normal levels at the end of the quarter, and then collapses once the new quarter begins.[18] As a whole, the dealer system is therefore delevering at the end of the quarter through sales to customers and then relevering once the new quarter starts, consistent with window dressing.

Furthermore, if dealers are deleveraging through the bond markets, we should expect an impact on market quality as measured by price impact. Froot and Stein (1998) predict that when capital constraints bind, intermediaries will offer worse prices to customers in transactions that increase their capital burden, and better prices for transactions that reduce their capital burden. Indeed, Naik and Yadav (2003) find that when market demand for securities brings dealers' positions closer to intraday capital limits, customers face significantly asymmetric effects on market quality. Window dressing is a self-imposed constraint on dealer leverage, which is only necessary at the end of the quarter, so the prediction of Froot and

[18]This may be due to window-dressing dealers seeking out less-levered dealers, and in a follow-up project, I examine newly available TRACE transactions data that includes dealer identities to definitively test this hypothesis.

Table 15.
Quarter-End Dealer Selling Pressure

The dependent variable is the settlement-adjusted daily total market volume in millions of dollars of dealer purchases from customers minus dealer sales to customers (column (1)), or of trades between two dealers (column (2)), in which the security was an agency bond. Regressors are indicator variables for the five days before and after a change in quarter. Data is obtained from WRDS TRACE. Each transaction is considered at the date of settlement rather than execution. Estimation is based on OLS regression. Bootstrapped heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Agency Bonds	(1)	(2)
Daily Market Volume ($ Millions)	Net Dealer Buying	Inter-Dealer Trading
Fifth-to-Last Day of	-253.1*	3,708
Quarter	(146.4)	(13,840)
Fourth-to-Last Day of	-598.8**	22,810***
Quarter	(236.1)	(8,487)
Third-to-Last Day of	-1,294***	80,000***
Quarter	(259.7)	(25,610)
Second-to-Last Day	-1,520***	108,100**
of Quarter	(425.5)	(43,220)
Last Day of Quarter	-1,534***	129,000**
	(556.6)	(63,860)
First Day of Quarter	408.2**	-19,070
	(191.5)	(14,940)
Second Day of	366.7**	-30,890***
Quarter	(172.4)	(8,940)
Third Day of Quarter	427.2***	-17,550
	(98.96)	(16,750)
Fourth Day of Quarter	97.41	-16,260**
	(144.5)	(6,358)
Fifth Day of Quarter	124.5	-12,040
	(177.7)	(8,265)
Constant	-1,125***	64,290***
	(30.89)	(2,227)
Observations	476	476
R-squared	0.341	0.221

Source: FINRA

Stein (1998) should therefore extend to a seasonal effect on market quality.

I compute the daily percent price change of each bond, as a function of the net dealer buying minus selling on that bond each day. However, individual bonds can trade very infrequently, so I look only at price changes when the bond has traded at least once that day and the day before. Dealers act as market makers in agency bonds, so typically a trade between a dealer and a customer is customer-initiated. Therefore, I expect a dealer buying from a customer to have a negative price impact. Indeed, Table 16 shows this is the case during normal times. However, in the five days before the end of the quarter, when dealers are selling heavily to customers, the price impact of selling to a dealer rises by 12%. Once the new quarter starts, the price impact in selling to a dealer decreases but is not significant. This appears to be consistent with a quarterly drop in market quality due to dealer window dressing.

Table 16.
Price Effects of Window Dressing Deleveraging Pressure

The dependent variable is the one-day percentage change in price of an Agency bond. Net directional volume is the daily total value of bonds bought by dealers from customers minus the total value of bonds sold by dealers to customers. This regressor is also interacted with pre- and post-quarter-end indicator variables which =1 for all of the 5 days before or after the change in quarter, respectively. Estimation is based on OLS regression. Heteroskedasticity-robust standard errors are presented in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% level, respectively.

	(1) Percent Change in Price
Net Directional Volume	-0.00731***
	(0.000136)
Net Directional Volume x Pre-Quarter-End	-0.000895*
	(0.000513)
Net Directional Volume x Post-Quarter-End	0.000690
	(0.000503)
Constant	0.000537***
	(1.19e-05)
Observations	394,660
R-squared	0.008

Source: FINRA

6.2 Money Market Mutual Funds

Agency bond markets see dealers selling assets for cash, but as shown earlier, money market funds have a surplus of quarter-end cash. Due to regulatory restrictions, money market funds cannot invest in long-dated securities such as agency bonds, so there is effectively a dislocation of cash in the markets each quarter. Repo is a conduit for short-term money to finance longer-term investments, and quarterly window dressing is a regular stress on this conduit. Money market funds have had to play a quarterly game of musical chairs to find short-term assets that they can roll out of when repo resumes at the start of the quarter. The Federal Reserve's reverse repurchase agreement program (RRP) was instituted in September 2013, and it appears to be facilitating this process.

In the current zero-interest-rate policy environment, the Fed funds market has become relatively inactive,[19] and the RRP was originally proposed as a new tool to impose a floor in interest rates by raising the repo rate. To do this, the Federal Reserve will lend collateral to cash suppliers (mostly money market funds), in essentially a tri-party repo transaction in which the Fed is the dealer.

Each quarter, the Federal Reserve has increased the amount of collateral it is willing to repo. Figure 5 shows that at the end of each quarter, cash from money funds surges into the RRP and immediately flows back out. On September 19, 2014, the Federal Reserve announced[20] (perhaps in an effort to make money funds less reliant on the Federal Reserve to help cope with window dressing) it would lower the cap on its reverse repo transactions to $300 billion, which sent rates on ultra-low Treasury bills maturing October 2 below zero. The RRP was intended to be a tool for raising interest rates by pulling cash out of the money markets, but at the end of the quarter, it seems the RRP is being overwhelmed by window dressing.

[19] Afonso, Entz, and LeSueur (2013) online: http://libertystreeteconomics.newyorkfed.org/2013/12/whos-lending-in-the-fed-funds-market.html

[20] http://online.wsj.com/articles/fed-rate-hike-tool-stirs-some-concern-1411164329

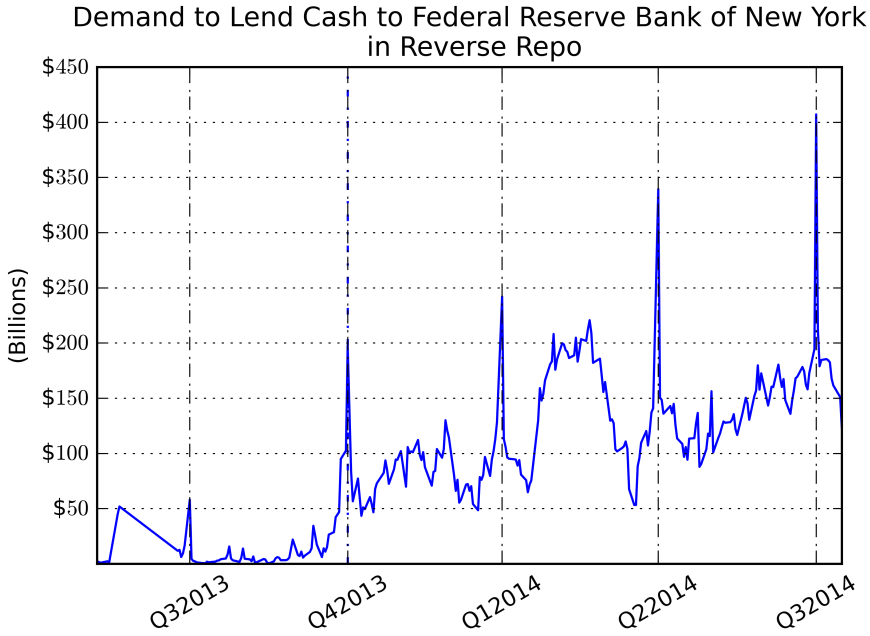

Figure 5. Daily Demand to Lend to the Federal Reserve Bank of New York

Notes: The vertical axis represents the value in billions of dollars of cash submitted in auction to the Federal Reserve Bank of New York (FRBNY) to finance collateral pledged by the FRBNY in an overnight repo each day through its Reverse Repurchase (RRP) program. The program was first discussed in a July 2013 policy meeting, early testing began August 7, 2013, and this chart shows submissions each day from then until October 15, 2014. Quarter-ends are marked with vertical dashed lines, and year-ends are marked with heavier dash-dotted lines. Almost every day, the amount submitted in auction was then used that same day to finance FRBNY collateral. The only exceptions to this are in mid-August 2013 when the program was still being tested and was limited to $5 billion, and on September 30, 2014, when the FRBNY limited the value of collateral it would pledge in repo to $300 billion.

Source: Federal Reserve Bank of New York

7 Conclusion

Non-U.S. bank dealers window-dress. The effect is not driven by cash lenders, and dealer leverage explains the quarter-end decline in repo. A joint model of supply and demand shows that non-U.S. dealers are voluntarily reducing their demand and do not face higher costs at

the end of the quarter as they would from reduced supply.

Window dressing understates a dealer bank's leverage and maturity mismatch, which means systemic risk is higher than we would believe using only quarter-end measures. Window dressing also creates spillovers into other markets, and dislocates cash from productive financial intermediation. Other agents can take advantage of this phenomenon: the end of the quarter is a very good time for bond funds to buy from dealers, although the round trip costs of trading with a dealer do not appear to allow an arbitrage-like opportunity. Morey and O'Neal (2006) find that bond mutual funds window-dress as well, by buying government bonds before disclosure; bank window dressing and bond fund window dressing may be complementary to each other.

This raises interesting implications for previous studies of the repo market during the financial crisis. Quantities (or prices) of repo borrowing cannot separately by themselves demonstrate a run on dealers. To really determine what's happening in repo, we need an integrated approach to looking at supply, demand, and especially at deleveraging pressures. In quarter-end window dressing, the effect is dealer-initiated. It is not clear whether the haircut spirals documented in Gorton and Metrick (2009) were driven by dealers unwilling to lend to hedge funds, or whether the dealers themselves were being forced to delever and wind down their repo operations. By collecting more data on bilateral repo transactions as well as investment flows from securities lending and segregated accounts, we may be able to better answer whether the 2008 crisis was a run on repo or whether repo behavior was simply a symptom of a deleveraging banking system.

My findings offer some clear policy recommendations as well. As part of the Basel III bank capital reforms, a new supplementary leverage ratio (SLR) is currently being implemented. U.S. regulators have announced they intend to calculate the SLR from the daily quarter average. However, outside the U.S., the SLR's current implementation will calculate the ratio from the average of the last day of each month in a quarter. Because non-U.S. banks are currently window dressing at the end of each quarter, it is very likely that a change

to using month-ends for capital regulation will simply increase the frequency of window dressing, with commensurate challenges for money market funds and other repo lenders. In other words, the frequency of reporting a regulatory ratio may matter as much as the required level of the ratio itself. Of course, Tier 1 and other regulatory ratios would also be more informative outside the U.S. if foreign banks switched to a quarter-average calculation as well.

SLR should be quarter-average, all capital requirements should be quarter-average. Fitch Ratings has claimed that making SLR a daily average instead of month-end average represents a concession to U.S. custodian banks.[21] However, this paper suggests that the opposite is true. Daily averaging of capital requirements disincentivizes window dressing, which improves the effectiveness of bank regulation.

The RRP appears to be absorbing significant cash each quarter-end that arrives due to window dressing. The RRP was intended to be a tool for increasing interest rates as an alternative to fed funds.[22] However, the September 17, 2014, announcement capping the RRP at $300 billion sent money market investors scrambling for alternative short-term investments for their anticipated excess cash from repo, and dropped yields on short-term Treasury bills into negative territory. By providing cash lenders with a safe repo counterparty when others window-dress, the Federal Reserve may be making those lenders dependent on the RRP at quarter-ends. If window dressing is not fixed, the Fed can at least modify the RRP to make it flexible during the quarter, increasing the amount of collateral financed at quarter-end to absorb the surge in cash, but then lowering it during the quarter to match the decrease in uninvested cash. The recent addition of term repurchase agreements to the RRP is likely effective in ameliorating this problem.

[21] Custodian banks are typically cash-rich banks, as opposed to most cash-poor dealer banks. https://www.fitchratings.com/gws/en/fitchwire/fitchwirearticle/US-Leverage-Rule .

[22] http://www.newyorkfed.org/markets/rrp_faq.html .

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Appendix of Additional Materials

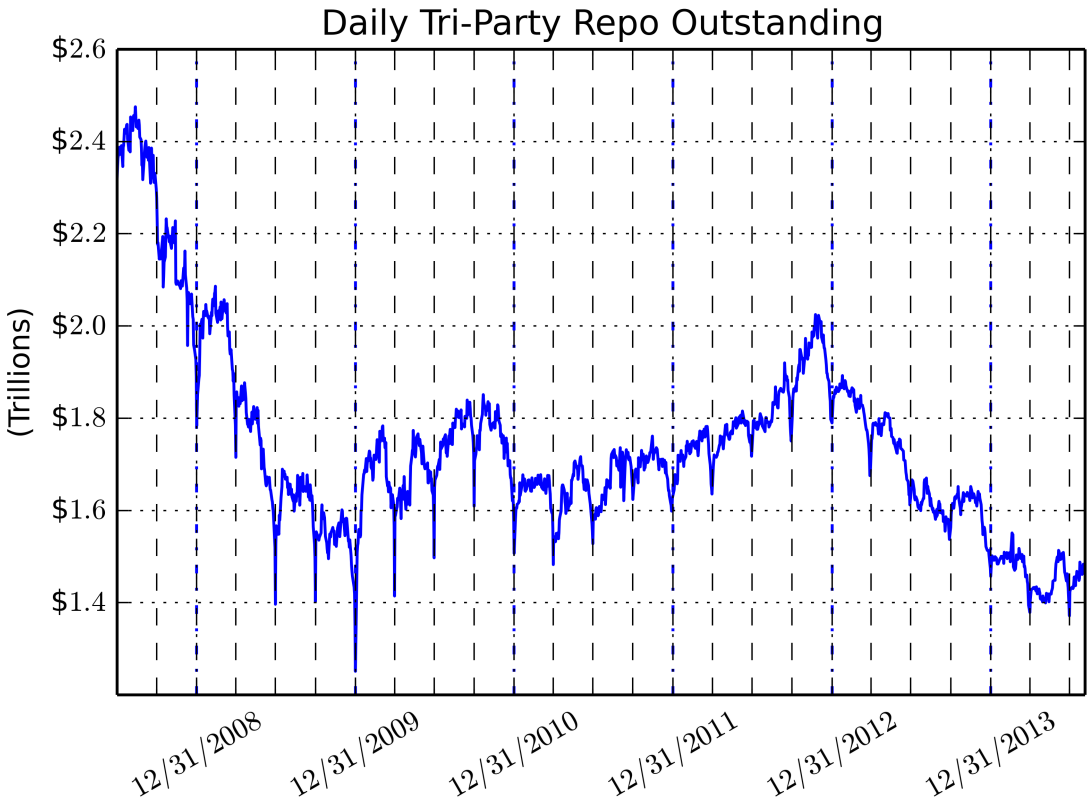

Figure 6. Daily Tri-Party Repo Outstanding

The vertical axis represents the value in trillions of dollars of collateral outstanding pledged in repo each day from July 1, 2008, to July 31, 2014. Quarter-ends are marked with vertical dashed lines, and year-ends are marked with heavier dash-dotted lines. I exclude repo borrowing by the Federal Reserve Bank of New York. Furthermore, I exclude the dates of 7/17/2008 and 4/11/2013, because of missing data from one of the clearing banks.
Source: Federal Reserve Board of Governors

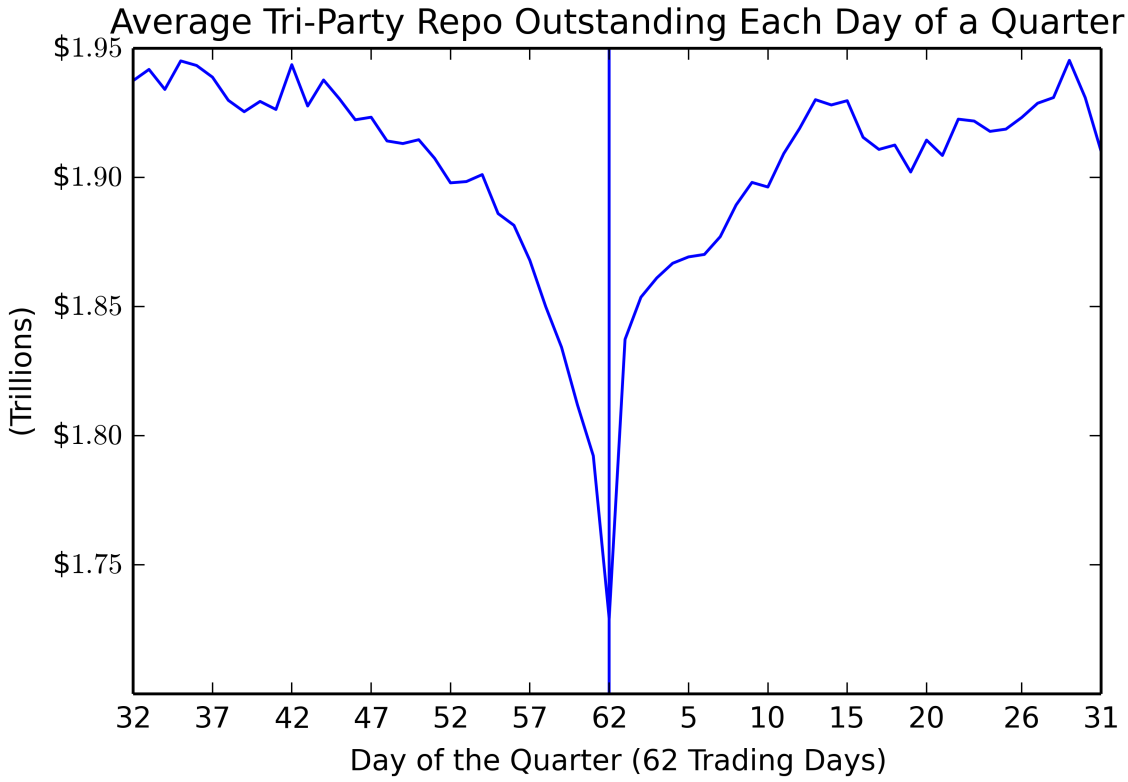

Figure 7. Average Tri-Party Repo Outstanding Each Day of a Quarter

This figure represents the average daily repo outstanding over the course of a single quarter. The average quarter has 62 trading days, and I position the end of the quarter (marked by a vertical line) in the middle of the figure to highlight the quarter-end decline and subsequent rebound of repo borrowing. The vertical axis represents the market value of collateral in trillions of dollars.
Source: Federal Reserve Board of Governors

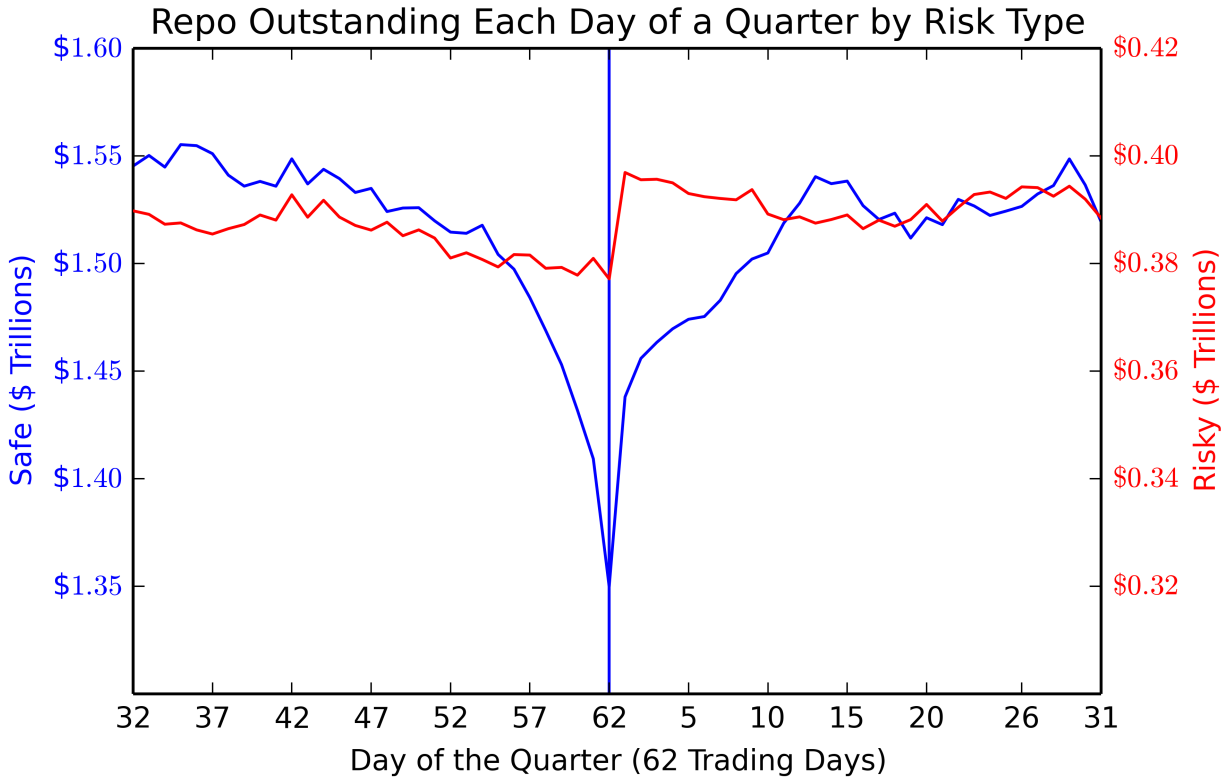

Figure 8. Repo Outstanding Each Day of a Quarter, by Type of Collateral

I separate the average repo outstanding over a single quarter by type of collateral. The solid blue line uses the left axis, and represents average repo borrowing backed by fed-eligible collateral: U.S. Treasuries, agency debentures, and agency mortgage-backed securities, and agency collateralized mortgage obligations. The dotted red line uses the right axis and represents average repo borrowing backed by all other types of collateral. Both axes are in trillions of dollars.
Source: Federal Reserve Board of Governors

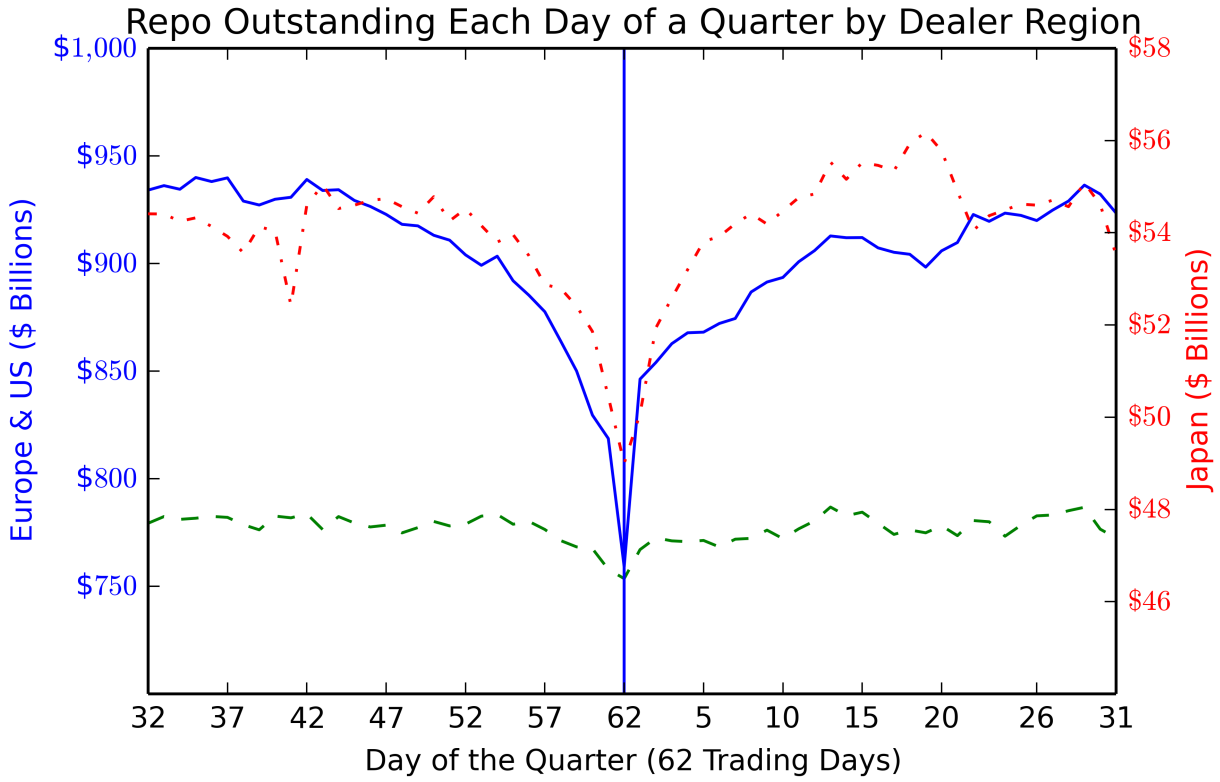

Figure 9. Repo Outstanding Each Day of a Quarter by Dealer Region

This figure presents the average repo outstanding over a single quarter separated by the region of the repo cash borrower (i.e., the dealer that is pledging collateral in the repo). The left and right axes are both in billions of dollars. I exclude non-bank dealers from this subplot. The dotted green line represents repo borrowing by U.S. bank dealers, and can also be distinguished by its distinct behavior: this line touches the left axis at roughly $780 billion and does not dip as markedly as the other two lines at the end of the quarter. The solid blue line represents repo borrowing by European bank dealers. Both U.S. and European bank dealer repo borrowing are in reference to the left axis. The dashed red line shows Japanese bank dealer repo borrowing, and because Japanese bank dealers are a much smaller segment of the repo market, I plot their line using the right axis.
Source: Federal Reserve Board of Governors