How Has Monetary and Regulatory Policy Affected Trading Relationships in the U.S. Repo Market?*

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We analyze the effects of changes in monetary and regulatory policy on trading dynamics in the U.S. triparty repo market. Using a confidential data set of transactions, we find that the Fed's reverse repo (RRP) facility led to a 16 percent reduction in cash lending by money market mutual funds (MMFs) eligible to transact with the Fed. We show that the RRP facility increased the bargaining power of MMFs on days when their borrowers, non-U.S. dealers, increased their window-dressing activity due to Basel III capital reforms. For those dealers reliant on eligible MMF funding, window dressing became more expensive, but the average rates they paid on other days remained stable because of anchoring by the facility. We also show that the RRP facility influenced the way MMFs managed their balance sheets, and directed them towards safer investments.

JEL Codes: C32, E43, E52.

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1. Introduction

Financial intermediaries rely on the repo market to finance the securities on their balance sheets. Persistent inability to fund these securities would lead to stress in money markets, as witnessed during the global financial crisis (GFC) of 2007–09. The repo market, which is a crucial source of short-term funding for many financial institutions, has been perceived as a potential source of instability since the GFC (see, for example, Adrian and Shin 2011, Copeland, Martin, and Walker 2014, and Gorton and Metrick 2012).

As part of its policy response to the GFC and the following Great Recession, the Federal Reserve (Fed) reduced the federal funds rate to its effective lower bound and conducted large-scale asset purchases (LSAPs) to provide accommodative financial conditions and promote economic recovery. The expansion of reserves due to LSAPs prompted changes in the way the Fed implements its monetary policy. In October 2008, the Fed starting paying interest on reserves, and this administered rate became its primary policy tool. In September 2013, the overnight reverse repurchase (RRP) facility was introduced to enhance rate control in an environment of abundant reserves. By offering a secured rate through the RRP facility where many counterparties, including money market mutual funds (MMFs), could lend to the Fed, the Fed effectively set a soft floor on repo rates (see Klee, Senyuz, and Yoldas 2019 for an analysis of how the RRP facility affected overnight funding rates).

During this time, the regulatory environment also evolved substantially. Prior to the GFC, broker-dealers (dealers), who are the main borrowers in the repo market, used to operate with substantial leverage, as they were not subject to strict regulatory limits. While capital requirements were much less restrictive than they are today, they were not uniform among dealers from different jurisdictions. For example, non-U.S. dealers did not have to meet a certain leverage ratio, unlike U.S. dealers. In the aftermath of the GFC, the international regulatory authority at Basel implemented a series of major financial reforms prompting banks and other financial intermediaries to reevaluate their risk-management practices. Among the new regulations, the Basel III capital reforms introduced a formal leverage ratio, requiring banks to hold Tier 1 capital equivalent to

at least 3 percent of their leverage exposure calculated using their on- and off-balance-sheet assets. These requirements directly affected the incentives and trading strategies of dealers, who typically borrow cash in the repo market to finance the securities on their balance sheets.

The regulatory requirements for dealers operating in different jurisdictions created different incentives for their activity in money markets. Munyan (2015) shows that pre-Basel III, non-U.S. dealers were already reducing their repo activity on financial reporting days, as their leverage ratios were based on quarter-end snapshots of their balance sheets. Their withdrawal from the market on financial reporting days is one form of the so-called window-dressing strategy that dates back to the 1800s.[1] The difference in regional implementation of the Basel III capital reforms further incentivized foreign dealers to engage in window dressing while it did not affect the U.S. dealers, which continued to report leverage ratios based on their daily activity.

In this paper, we analyze how these changes in U.S. monetary policy implementation and Basel III capital reforms affected the activity of two major repo market players: (i) MMFs—the primary cash lenders, and (ii) dealers—the primary cash borrowers. We use a confidential data set of repo transactions at the intradaily level in the triparty market, which is a major repo segment where a third party provides custodial services for operational efficiency. Our sample covers the period from January 2013 until August 2016, during when the RRP facility was introduced and the Basel III leverage ratio implementation took place.

On the supply side of the repo market, we show that the introduction of the overnight RRP facility led to a reduction of lending by MMFs eligible to transact with the Fed. These lenders compared the

[1]Financial institutions have historically modified the composition or size of their balance sheets ahead of their quarter-end filings to report more favorable ratios to their regulators or to the public. This phenomenon has been well-documented in the literature: see, for example, Agarwal, Gay, and Ling (2014), Allen and Saunders (1992), Lakonishok et al. (1991), and Sias and Starks (1997), among others. Prior to the GFC, an important motivation for window dressing was to improve the profitability measures mainly for public reporting. However, financial intermediaries started focusing more on the capital and liquidity measures in the more stringent post-crisis regulatory environment.

return for their cash investments in the private market and the RRP offer rate, and typically invested at the facility when the offer rate was more favorable relative to other options. On quarter-ends, when non-U.S. dealers pulled back from the market to reduce the size of their balance sheets for financial reporting, the facility provided a backstop to eligible MMFs to place their excess cash. We show that cash supply in the repo market provided by eligible MMFs declined by 16 percent, on average, after the inception of the facility. On the demand side, we show that after the Basel III leverage ratio implementation, window-dressing activity by European dealers increased by about 19 percent. With this increase in window dressing, total reduction in repo borrowing on financial reporting days reached 30 percent.

The inception of the RRP facility and the intensified window-dressing activity by European dealers constituted a supply shock and a demand shock in the repo market, respectively. Putting these shocks together, we show that window dressing became more expensive for dealers reliant on eligible MMF funding in comparison with dealers that were less reliant. Further, reliant dealers were unable to reduce their borrowing as much on financial reporting days. However, on other days, dealers reliant on eligible MMF funding ended up paying, on average, similar rates to their MMF lenders in comparison with dealers that were less reliant, because of the anchoring effect of the RRP facility. Our results highlight the importance of trading relationships and how these relationships affected bargaining power dynamics in the triparty repo market.

Finally, we examine the implications of the RRP facility for balance sheet management of MMFs. Using Securities and Exchange Commission (SEC) N-MFP filings, we find evidence that the inception of the RRP facility made eligible MMFs safer, as they shifted the composition of their balance sheets towards Treasury repo and away from repo backed by other collateral, commercial paper (CP), asset-backed commercial paper (ABCP), or corporate debt. Further, we find some evidence that ineligible MMFs shortened the duration of their portfolios after the inception of the facility, likely reflecting their strategy to rely more on shorter-duration investments, as they did not have the RRP facility available as a backstop.

Our work contributes to the growing literature on repo market dynamics. Adrian and Shin (2011) and Macchiavelli and Zhou

(2019) show that dealers rely on repo for short-term funding needs and adjust the size of their balance sheets mainly through their activity in this market. Focusing on different market segments, Copeland, Martin, and Walker (2014), Gorton and Metrick (2012), Krishnamurthy, Nagel, and Orlov (2014), and Martin, Skeie, and von Thadden (2014) analyze repo market dynamics during the GFC. Regarding the effects of the RRP facility in money markets, Anderson and Kandrac (2018) argue that eligible funds were able to command higher rates during the testing phase of the facility. Using transaction-level data for all MMFs investing at the facility over a much longer horizon, we show that the RRP facility did not lead to differential pricing. Our finding is consistent with Klee, Senyuz, and Yoldas (2019), who show that the facility rate anchored rates in the repo market.

Our work also contributes to the vast literature on the importance of trading relationships in different financial market segments: Han and Nikolaou (2016) for the repo market; Afonso, Kovner, and Schoar (2014) and Cocco, Gomes, and Martins (2009) for the interbank market; Bharath et al. (2011) and Dass and Massa (2011) for bank-firm relationships; and Chernenko and Sunderam (2014) for MMF lending, among others.

Another strand of literature that our paper is related to focuses on the effects of the network structure in over-the-counter (OTC) markets on prices. Hendershott et al. (2016), Li and Schürhoff (2019), Maggio et al. (2019), Maggio, Kermani, and Song (2017), and Neklyudov (2019) all show that dealers that are less interconnected in the OTC network are unable to charge their clients more. We document the increase in bargaining power of eligible MMFs after the RRP facility was introduced, as their dependence on dealer borrowing declined, and show that strong relationships prevented some dealers from window dressing as effectively. Our results are also consistent with Babus and Hu (2017) and Gofman (2017), who show that if a network becomes less interconnected, it also becomes more stable. We provide some evidence that when MMFs became less dependent on dealers, their investments shifted towards safer investments. Finally, our results on the effects of increasing bargaining power of MMFs also provides empirical evidence for the theoretical results shown in Duffie, Gârleanu, and Pedersen (2005, 2007) in the search-and-bargaining literature.

The rest of the paper proceeds as follows. The next section provides background information on the repo market and the Fed's RRP facility. Section 3 describes the confidential data set of repo trading and the control variables for the empirical analysis. The effects of the RRP facility on MMF lending are documented in Section 4. Section 5 turns to the demand side of the repo market and analyzes the effects of Basel III capital regulations on dealer behavior. Section 6 investigates how the changes in the Fed's monetary policy framework and regulatory framework affected bargaining power in trading relationships. Section 7 examines the implications of the RRP facility for MMFs' balance sheet management. Section 8 concludes.

2. The Repo Market and the Policy Environment

2.1 Repo Market Mechanics

A repo transaction facilitates the sale and future repurchase of a security that serves as collateral between the two parties: (i) the borrower who owns a security and seeks cash and (ii) the lender who receives the security as collateral when lending the cash. The cash borrower sells securities to the cash lender with the agreement to repurchase them at the maturity date. On the maturity date, the borrower returns the cash with interest to the lender and the collateral is returned from the lender to the borrower.[2] In the event of a default, the cash lender can sell the cash borrower's collateral to recover the loan amount.

The repo market during our time period can be divided into two broad segments: the bilateral market and the triparty market, where all types of securities are used as collateral. In the bilateral market, lenders and borrowers interact directly to negotiate the terms of the trade, settle the trade, and organize all back-office support themselves. In the triparty market, lenders and borrowers use the services of a third party to act as a custodian, settle the trade, and provide all back-office support. In the triparty repo platform for our sample

[2]From the cash borrower's perspective, this transaction is called a repo, and from the cash lender's perspective, it is called a reverse repo. Fed transactions in the repo market are defined as the opposite of market convention. If executed by the Fed, a cash-out/securities-in transaction is called a "repo" and a cash-in/securities-out transaction is called a "reverse repo."

period, two clearing banks—Bank of New York Mellon (BNYM) and J.P. Morgan (JPM)—provided these back-office services.

Our analysis focuses on the triparty market for which we have daily transaction data. The overall daily triparty repo volume, which includes trades of all maturities and collateral types, was around $2 trillion during our sample period. More than $1.5 trillion of this volume involved general collateral (GC).[3] GC repo transactions are backed by securities that meet the predetermined eligibility criteria to be accepted as collateral. The cash lender does not know the specifics of the securities collateralizing the transaction prior to settlement, as opposed to a specific collateral repo where the cash lender typically tries to obtain a particular security. While other collateral types are also traded in the triparty segment, we focus on GC repo transactions in the triparty market where the collateral include U.S. Treasury securities, agency debt, and agency mortgage-backed securities (MBS). GC repo is the largest, safest, most liquid, and primarily overnight.

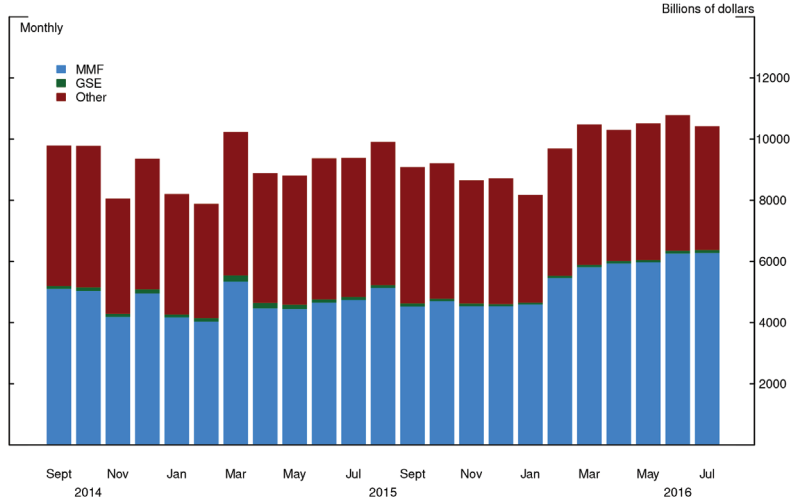
Figure 1 shows the monthly totals of overnight GC triparty transaction volumes by lender types. As shown by the gray shaded bars, MMFs account for about 60 percent of overnight cash lending. The repo market is also an important investment platform for government-sponsored enterprises (GSEs), which constitute about 5 percent of the total monthly volume. All other types of cash lenders account for the remaining 35 percent of the volume. These lenders include mutual funds, asset managers, and hedge funds.

On the demand side of the triparty market, the main cash borrowers are dealers. Figure 2 shows the monthly totals of overnight GC triparty transaction volumes by U.S. and foreign dealers (includes European, U.K., Canadian, and Japanese dealers). Borrowing activity by the two dealers groups have been following parallel trends suggesting that, on average, they have been responding to broad market factors similarly.

The triparty GC repo market also includes the overnight RRP operations by the Fed and the general collateral finance (GCF) segment, which is a blind-brokered, interdealer repo platform that provides funding for dealers that may not have sustainable access to

[3]See Copeland, Martin, and Walker (2014) for a more detailed discussion of the mechanics of the triparty repo market.

Figure 1. Triparty GC Repo Lending by Lender Type



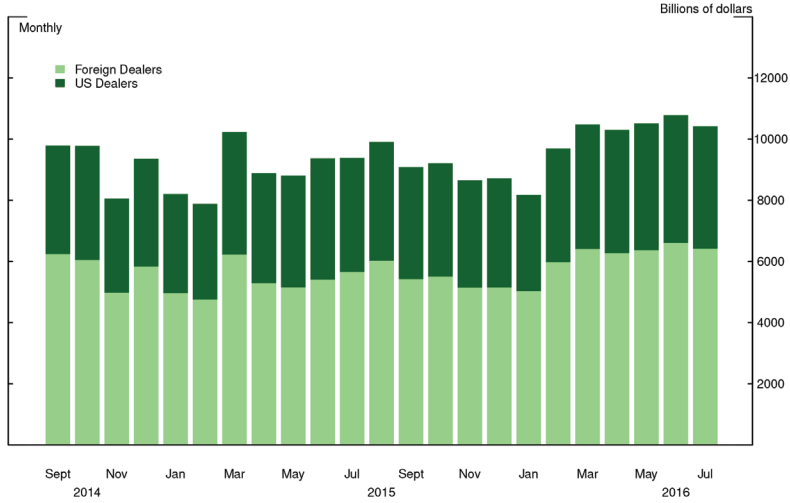
Note: This figure displays monthly totals of overnight triparty lending against GC by lender type. Data are overnight daily triparty repo transactions, obtained from FRBNY, and aggregated monthly. The sample shown here is from August 2014 to August 2016. "MMF" include money market mutual funds. "GSE" are government-sponsored enterprises such as Fannie Mae and Freddie Mac. "Other" includes asset managers, hedge funds, and mutual funds.

cash in the broader triparty market. Figure 3 shows an organizational diagram of the triparty GC repo market with the approximate shares of three segments from 2014 to 2016: (i) triparty market where BNYM and JPM serve as the custodian banks (70 percent of volume), (ii) interdealer GCF market (15 percent of volume), and (iii) transactions with the Fed via the RRP facility (15 percent of volume). In our triparty repo analysis, we exclude the interdealer GCF market as well as transactions with the Fed via the RRP facility.

2.2 Fed's RRP Facility

During the GFC and its aftermath, the Fed increased the size of its balance sheet through several liquidity facilities and LSAPs.

Figure 2. Triparty Repo Borrowing by Dealers



Note: This figure displays monthly totals of overnight triparty lending against GC by lender type. Data are overnight daily triparty repo transactions, obtained from FRBNY, and aggregated monthly. The sample shown here is from August 2014 to August 2016. Foreign dealers include European, U.K., Canadian, and Japanese dealers.

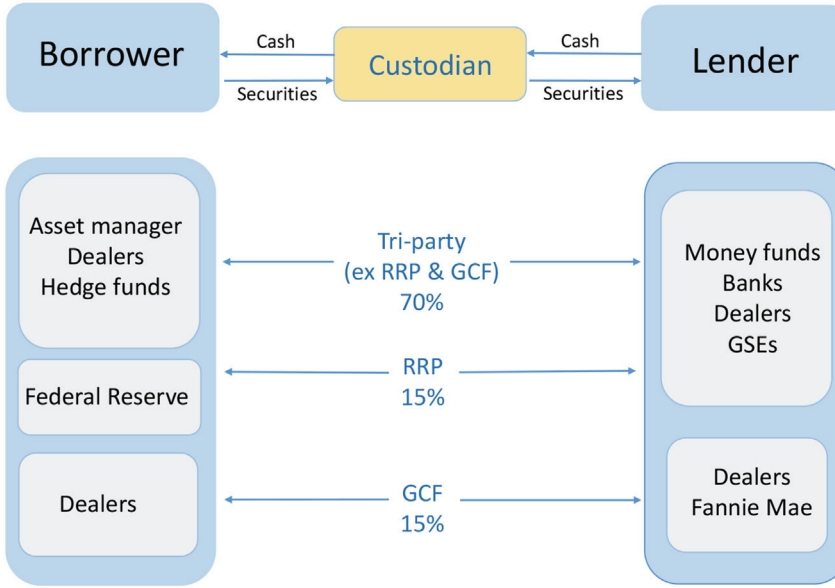
As a result, reserves in the financial system have reached unprecedented levels, resulting in a change in the Fed's monetary policy implementation.[4]

In October 2008, the Fed started paying interest on excess reserves (IOER) to banks that have accounts at the Fed, and the IOER became the primary tool of the new policy framework. However, the IOER could not set an effective floor for the federal funds rate because of the fragmented market structure. In September 2013, the Fed introduced the overnight RRP facility as a supplementary tool of its new policy framework to enhance monetary control.

The Fed has been offering overnight RRPs on a daily basis at a preannounced rate since September 2013. Through this facility, the Fed borrows cash from eligible counterparties in exchange for Treasury securities in its portfolio. These transactions take place with

[4]See Ihrig, Weinbach, and Meade (2015) for details of the Fed's monetary policy implementation framework during and after the crisis.

Figure 3. Triparty Repo Market Mapping



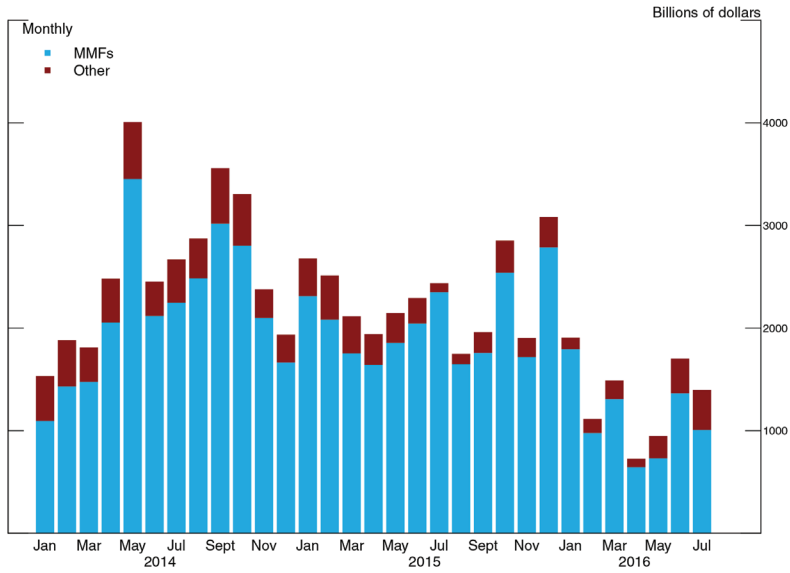
Note: The triparty GC repo platform consists of repo transactions for which BNYM and JPM are the custodian banks, interdealer transactions that take place in the GCF segment, and transactions with the Fed via the RRP. Shares of each segment shown above reflect approximate averages over the period from 2014 to 2016. These shares fluctuate on certain calendar days, such as quarter-ends. Since mid-2016, GCF volume has dropped significantly with the rise of the Fixed Income Clearing Corporation delivery-versus-payment segment. The data are from FRBNY and Bloomberg.

the agreement to repurchase the same security at a specified price at a specific time in the future. Overnight RRPs are offered to a broad set of financial institutions including nonbank cash lenders in the repo market, such as MMFs.[5]

Figure 4 shows the composition of participants coming to the facility from January 2014 to August 2016. MMFs were the primary participants, accounting for the majority of takeup at the facility.

[5]There are currently more than 150 RRP counterparties including MMFs, GSEs, primary dealers, and other banks. A list of RRP counterparties and information on eligibility requirements can be found at https://www.newyorkfed.org/markets/rrp_counterparties.html.

Figure 4. Overnight RRP Participation

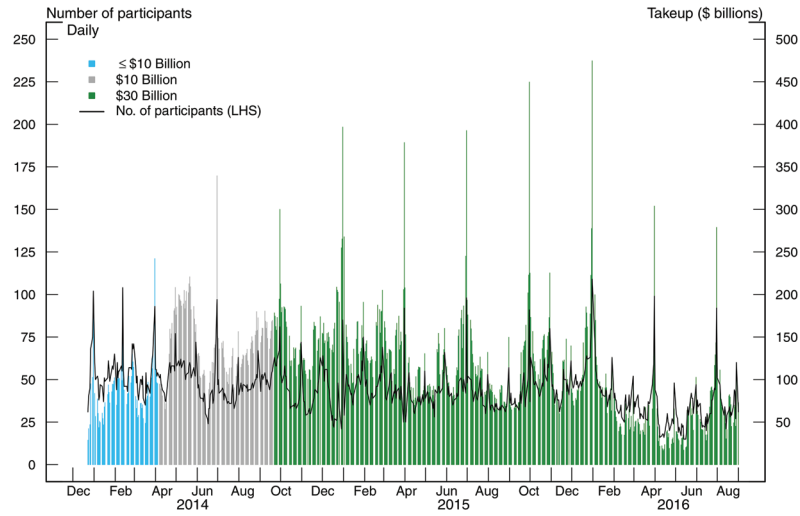


Note: This figure displays monthly totals of RRP participation by counterparty type. Data on overnight RRP takeup by counterparty type are available from FRBNY. The monthly sample shown here is from January 2014 to August 2016.

MMFs are the biggest cash lenders in the repo market and view the overnight RRP facility as a low-return and low-risk investment compared with lending to dealers.[6] The RRP facility provided a convenient alternative investment vehicle for MMFs who compared the facility's offering rate with other rates in the market and determined whether to participate in the overnight RRP operation offered each day. As MMFs would be unwilling to lend in the market at any rate below the RRP rate, the offering rate at the facility helped establish a floor for overnight funding rates, as shown by Klee, Senyuz, and Yoldas (2019). Most importantly, when dealers withdrew from overnight funding markets on quarter-ends for financial reporting purposes, the RRP facility provided a backstop for MMFs.

[6] Among other counterparties, GSEs account for most of the remaining takeup, with Fannie Mae and Freddie Mac increasing their facility usage on days ahead of their principal and interest payment dates.

Figure 5. RRP Facility Usage



Note: This figure displays daily RRP takeup from both overnight and term RRP operations. Data on overnight and term RRP takeup are available from FRBNY. The daily sample shown here is from December 23, 2013 to August 1, 2016.

Figure 5 shows the daily RRP takeup after the individual bid size increased to $3 billion on December 23, 2013. Takeup at the facility was very low in the first few months of testing, during which the facility parameters were modified frequently. Following gradual increases in the bid size over a few months, facility takeup increased. For our sample from January 2013 to August 2016, average daily volume was around $100 billion.[7] Seasonal spikes correspond to quarter-ends, when total RRP takeup hit record levels as MMFs shifted their lending to the Fed due to reduced demand for repo financing.

[7]Investment capacity at the facility proved to be an important factor affecting repo rates, especially on quarter-ends. Before the September 2014 quarter-end, the Fed introduced an overall cap of $300 billion, which led to a sharp drop in repo rates as cash lenders scrambled for alternative investments. A series of term RRPs were conducted ahead of quarter-ends to provide extra capacity to RRP counterparties until late 2015. The facility cap was lifted in December 2015 and there have been no term RRP operations over quarter-ends since then. Throughout the paper RRP refers to the sum of overnight and term operations.

Further details on the design of the overnight RRP facility can be found in Frost et al. (2015).

3. Data

3.1 Triparty Repo Transaction-Level Data Set

Our confidential data set of daily triparty repo transactions of overnight maturity backed by GC which is available from January 2, 2013, to August 1, 2016, allows us to examine the implications of the new policy environment on the repo market.[8] These data are reported by BNYM to the Federal Reserve Bank of New York (FRBNY).[9] We examine repo transactions backed by Treasury securities, agency debt, and agency MBS, and of overnight maturity.

To fully analyze MMF-dealer trading dynamics, it is necessary to identify those funds that are eligible to lend to the Fed via the RRP facility among all MMF lenders in the data set.[10] However, identification of eligible lenders is challenging, as lender names are not uniform throughout the data set, and one must identify funds at the fund rather than complex level to determine the eligible funds. In our data set, a single fund may be listed in multiple ways. For example, Money Fund A may appear as "mmf A," "moneyf A," "moneyfunda," etc. To collapse the multiple ways a money fund may appear in the data set to the appropriate fund, we use the monthly SEC Form N-MFP filings for MMFs, which provide monthly snapshots of MMF fund-level repo transactions including the volume, collateral, price, and maturity of the trade. We are able to match the various lender strings in our transaction-level data set to a single

[8]We end our sample at August 1, 2016 to avoid data issues of MMF fund closures from the compliance of SEC MMF Reform in mid-October 2016.

[9]During this time period, BNYM was a custodian for about 80 percent of trades in the triparty repo market. BNYM started providing daily transaction-level data after August 22, 2014. Prior to this date, BNYM used to provide a Tuesday snapshot of all outstanding open trades, for which it acts as custodian. For this period we merged Tuesday snapshots with the daily transaction data and use day fixed effects to account for the cross-sectional snapshots in our analysis. We sum all transactions for a given lender-borrower pair at the daily level.

[10]Since the list of RRP-eligible counterparties has changed over time, we use a dynamic list of eligible funds. See https://www.newyorkfed.org/markets/rrp_counterparties.html for the up-to-date list of eligible counterparties.

Table 1. Summary Statistics for Triparty Transaction-Level Data

Items	No. of Transactions
Eligible MMFs	71,322 (41%)
Ineligible MMFs	100,636 (59%)
Foreign Dealers	104,358 (61%)
U.S. Dealers	67,600 (39%)
Transactions	171,958
Treasury Securities	87,704 (51%)
Agency Securities	84,254 (49%)

Note: This table displays summary statistics about the triparty transaction-level data set. Data are obtained from FRBNY. The data are reported by Bank of New York Mellon to FRBNY, and available from January 2, 2013, to August 1, 2016.

fund by matching the volume, collateral, maturity, and price of the repo transaction on these month-end N-MFP filing days.[11]

We are able to match 288 MMFs and 25 dealers. Of the approximately 60 percent of transaction volume that are likely MMF lenders, we can identify the MMF lenders and dealers of 82 percent of these transactions (see Figure 1). Consequently, our data correspond to about 50 percent of the total volume in the triparty repo market. We identify a total of 1,101 unique MMF-dealer pairs. As reported in Table 1, eligible and ineligible MMFs account for 41 percent and 59 percent of these transactions, respectively. Foreign dealers (European, U.K., Japanese, and Canadian) participate in 61 percent of transactions (16 dealers) while the U.S. dealers (9 dealers) account for the remaining volume. Our data set consists of trades backed by Treasury (51 percent) and agency securities (49 percent).

[11] We merge repo transactions with N-MFP filings on October 31, 2014; November 30, 2014; and December 31, 2014. A fund is considered matched if we match overnight repo volumes within a 1 percent error given collateral type, maturity, and price. By using only three N-MFP filing dates, we do assume some static MMF lending in our data set. Because the string match between the N-MFP filings and the repo transaction-level data set is quite intensive, and we match 82 percent of transaction volume on these dates, we are comfortable with our methodology.

3.2 Control Variables

We construct several control variables to establish robustness of our empirical results, where we refer to dealer i on day t. First, using the quarterly Consolidated Report of Condition and Income Reports from the Federal Financial Institutions Examination Council (FFIEC), or Call Reports, we construct two balance sheet measures for each dealer borrower i at quarter q: (i) dealer's total assets ($TotalAssets_{i,q}$), (ii) dealer's short-term funding dependence ($STFD_{i,q}$), calculated as follows.[12]

$$STFD_{i,q} = \frac{(ST\ Noncore\ Funding)_{i,q} - (ST\ Investments)_{i,q}}{(LT\ Assets)_{i,q}}. \tag{1}$$

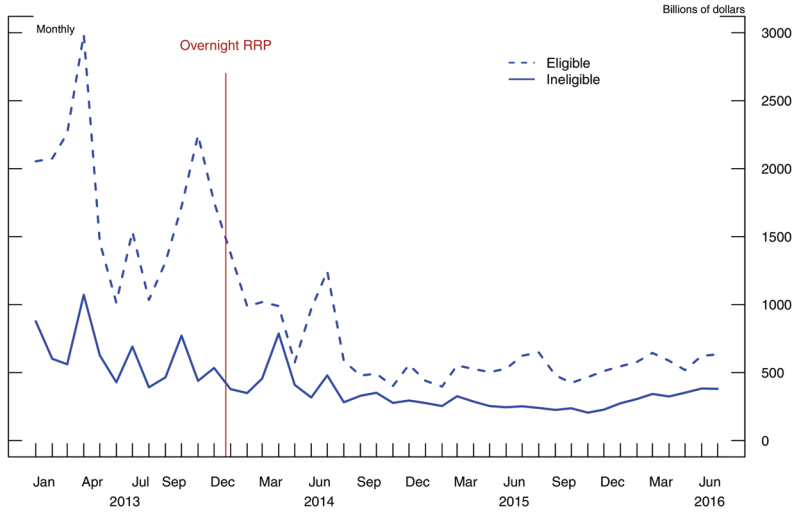
Second, we construct control variables for the lenders (MMFs) using the SEC N-MFP filings to calculate MMF complex total assets under management (AUM), Treasury repo investments, and the amount of Treasury securities held. N-MFP filings are filed monthly by each MMF fund. These control variables capture MMFs' dependence on lending in repo markets and their preference for lending in Treasury repo versus holding Treasury securities outright, which are close substitutes.

4. The RRP Facility and Cash Supply

We first analyze how the introduction of the overnight RRP facility affected cash lending in the repo market by eligible versus ineligible MMFs. When the Fed started test operations at the facility, it released a list of eligible counterparties. Those MMFs that are eligible to participate to lend to the Fed via the overnight RRP compared

[12]STFD was developed by bank supervisors as a measure of banks' short-term funding dependence. See pages 3–6 of https://www.federalreserve.gov/boarddocs/supmanual/bhcpr/UsersGuide13/0313.pdf for specific definitions of the variables. Total assets is item RCFD2170 on FFIEC 002 or FFIEC 031; or item RCON2170 on FFIEC 041 or FFIEC 051. Call Report data are available for 19 of the 25 dealers in the triparty repo market. The remaining participants do not have commercial bank operations in the United States and, therefore, do not need to report regulatory ratios to the FFIEC.

Figure 6. MMF Lending



Note: This figure displays weekly totals of MMF lending in overnight triparty repo backed by GC. Data are daily overnight triparty repo transactions backed by GC, obtained from FRBNY, and summed weekly. The weekly sample is from January 1, 2013, to August 1, 2016. We estimate total weekly lending before August 22, 2014 (when daily data are available) from Tuesday snapshots of triparty transaction data.

the offering rate at the facility with private market rates and determined whether to participate in the RRP operation offered each day. In addition to the spread between the RRP offer rate and market rates, calendar factors also affected facility usage. When dealers, the major repo borrowers, contracted their balance sheets on financial reporting days, eligible MMFs could invest their surplus cash at the RRP facility, while ineligible MMFs were forced to find other investment opportunities in the private market.

Figure 6 shows weekly lending by eligible and ineligible MMFs from January 2, 2013 to August 1, 2016. Both series are trending down during the first half of the sample, likely reflecting factors such as the low rate environment, the implementation of more conservative risk measures, and the third round of LSAPs by the Fed which reduced the supply of Treasury collateral in the market. To quantify the MMF response to the RRP, we first test for unit roots in the

MMF lending series using Elliott, Rothenberg, and Stock (1996) and Ng and Perron (2001) and tests that are powerful against persistent alternatives. We fail to reject the null of unit root due to the presence of breaks in both series.[13] After confirming that the series do not exhibit unit-root behavior once the breaks are accounted for, we regress them on their respective break dates and retrieve the residuals, which are stationary. We then estimate the following regression for weekly MMF repo lending, RL_t:

$$RL_t = \beta_0 + \beta_1 RL_{t-1} + \psi_1 RRP1 + \psi_2 RRP2 + \epsilon_t, \qquad (2)$$

where RRP1 takes the value 1 for the weeks from September 23 to December 23, 2013 and 0 otherwise, to represent the initial testing period of the facility. During this time, takeup was very low amid small bid limits which were then increased gradually. The individual bid size reached $5 billion on December 23, 2013, and takeup increased to levels consistent with the sample average. Our second indicator variable, RRP2, marks the beginning of the period during which the facility started to be perceived as a viable investment option by market participants. We also account for autocorrelation by including the first lag of repo lending.

As shown in Table 2, we do not find a significant response of MMFs to the inception date of the facility as captured by RRP1, although we find evidence of a shift in eligible MMF in response to RRP2. Once the RRP facility became a significant investment option with increased individual caps, eligible MMF lending declined by an average of 16 percent. While we find a significant effect of RRP facility on eligible MMF lending, we do not find any effect on ineligible MMF lending. These results are unlikely to be driven by dealer demand since overall repo borrowing remained steady during our sample period.

To quantify the extent of substitution between eligible MMF investments in the private repo market and at the RRP facility, we

[13] Perron (1989) points out that conventional unit-root tests are biased towards a false unit-root null when the data are stationary and include a structural break. See Hansen (2001) for a comprehensive review of the literature on structural breaks. We find evidence of breaks in both series using the Quandt-Andrews unknown breakpoint test. We find the break dates of 2014:W28 and 2014:W17, for eligible and ineligible lending, respectively. For brevity, we do not report the unit root and the structural break test statistics.

Table 2. Effects of RRP on Repo Lending to Dealers

	Eligible MMF (1)	**Ineligible MMF (2)**
RRP1	0.03	–0.08
	(0.25)	(–0.8)
RRP2	–0.16***	–0.10
	(–2.32)	(–1.56)
Repo Lending (–1)	0.45***	0.30***
	(6.31)	(4.01)
Observations	180	180
R^2	0.27	0.11

Note: This table presents the results of time-series regressions for the log of weekly repo lending by MMFs to dealers. The weekly sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. Dealers comprise all foreign and U.S. dealers in our sample. RRP1 takes the value 1 from September 23, 2013, to December 23, 2013 and 0 otherwise. RRP2 is equal to 0 until December 23, 2013, and 1 thereafter. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. *t*-ratios are reported in parentheses and are calculated using robust standard errors.

estimate a time-series regression for the log of private repo lending by MMFs, shown in Equation (3), where we have the first lag of RRP facility takeup as an explanatory variable along with the first lag of the dependent variable. This specification is estimated using daily data from August 22, 2014 to August 1, 2016.[14]

$$RL_t = \beta_0 + \beta_1 RL_{t-1} + \psi_1 RRP_{t-1} Takeup + \epsilon_t \tag{3}$$

Table 3 shows the results of this estimation. We find that while overall repo lending by eligible MMFs declined by 16 percent, about 9 percent of this decline was replaced by investments in the RRP facility. On average, a one-standard-deviation increase in RRP

[14]We focus on the sample after daily data collection has started on August 22, 2014, to avoid the break in the data due to changes in data collection. Also, in this part of the sample, the RRP facility was well established as an alternative investment option for cash lenders in the repo market with sufficient counterparty limits, which helps us get a clean read on the extent of substitution between investing in the repo market and in the RRP facility.

Table 3. Effect of RRP on Repo Lending to Dealers

	Eligible MMF (1)
RRP Takeup (–1)	–0.09***
	(–3.88)
Repo Lending (–1)	0.34***
	(2.86)
Observations	477
R^2	0.0923

Note: This table presents the results of a time-series regression for the log of daily repo lending by MMFs to dealers. The daily sample runs from August 22, 2014, to August 1, 2016, and is obtained from FRBNY. Dealers comprise all foreign and U.S. dealers in our sample. RRP Takeup(–1) is the log of takeup by eligible MMFs the day prior. Repo Lending(–1) is the log of volume lent by eligible MMFs to dealers the day prior. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. *t*-ratios are reported in parentheses and are calculated using robust standard errors

takeup is associated with a 9 percent decline in repo lending by eligible MMFs, showing strong evidence of substitution between repo lending and investing at the RRP facility.

5. Basel III Capital Regulations and Cash Demand

In this section, we turn to the demand side of the triparty repo market and analyze how Basel III affected dealer behavior on financial reporting days. Dealers in the triparty repo market have typically exhibited some form of window-dressing behavior. Adrian and Shin (2010, 2011) show that dealers adjust the size of their balance sheets mainly through short-term repo borrowing. Prior to the GFC, dealers used to operate with substantial leverage, as they were not subject to binding regulatory limits. When regulators responded to the GFC with requirements of higher-quality assets and lower leverage, dealers were prompted to reevaluate their risk-management practices and adjust their balance sheet management. As a result, dealer risk-taking has moderated since the GFC (see Adrian et al. 2013).

Basel III capital reforms formally introduced a leverage ratio, requiring banks to hold Tier 1 capital equal to 3 percent of an

exposure measure which includes on-balance-sheet assets and certain off-balance-sheet items, including repo transactions. The calculation of the leverage ratio depends on banks' jurisdictions. Although the Basel III capital reforms were determined by an international body, each country could decide how they choose to implement their own version. In the United States, it is implemented as the supplementary leverage ratio (SLR), which is calculated on a daily basis. For European banks, the leverage ratio was computed as an average of the three month-end values over the quarter until October 2014 when the rule was amended to require only quarter-end reporting. U.K. dealers have been reporting their leverage ratios based on quarter-end snapshots of their balance sheet until they switched to reporting based on daily averages in January 2016. For other foreign banks, such as Canadian and Japanese banks, their leverage ratio was calculated as a quarter-end snapshot. Therefore, European and most other foreign dealers have been subject to less stringent implementation of the Basel III leverage ratio than to U.S. dealers.

The difference in regional implementation of the Basel III leverage ratio created different incentives for U.S. dealers and other dealers for financial reporting purposes. If the leverage ratio is calculated on a month- or quarter-end basis, then banks are likely to contract the size of their balance sheets on these dates and expand it on other days. While foreign banks in most jurisdictions are incentivized to engage in window dressing because of the less stringent leverage ratio implementation, U.S. dealers which report leverage ratios based on daily values do not have any reason to do so.[15] All else equal, in the absence of this difference in regional implementation of the leverage ratio, we would not expect repo trading behavior to be different between U.S. and non-U.S. dealers on reporting days.

Appendix A describes our empirical model that quantifies how much European dealers pulled back their borrowing in triparty repo

[15]Basel III also introduced two liquidity measures: the liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR). The LCR required banks to hold high-quality liquid assets sufficient to meet a 30-day liquidity stress scenario, and the NSFR complemented it by promoting liquidity buffers over a longer horizon. Although LCR requirements may have affected repo activity for collateral other than Treasury securities, there have been no implications for repo backed by Treasury collateral. Moreover, all banks are required to be compliant with LCR on a daily basis.

on regulatory reporting days, specifically quarter-end days, after the implementation of Basel III. Table A.1 in Appendix A reports the estimation results from July 1, 2008, to August 1, 2016, for European and U.S. dealers in columns 1 and 2, respectively. European dealers have already been reducing their borrowing by about 12 percent on the days leading up to quarter-ends, and an additional 11 percent on quarter-end days. We find that European dealers further reduced their repo borrowing by 19 percent on the quarter-end day after Basel III was implemented, implying a $122 billion drop in European dealer borrowing. The total decline in European dealer repo borrowing on quarter-end days was, on average, 30 percent in the post-Basel III period. While these dynamics are strongly pronounced for European dealers, there is no significant pattern for U.S. dealers at or around quarter-ends, and no change in their patterns following the implementation of Basel III leverage ratio.

The increased window-dressing activity by European dealers post-Basel III introduced a demand shock into the repo market, and thus it allows us to estimate whether non-U.S. dealers had to pay a premium to keep their relationships stable with their cash lenders when they increased their window-dressing activity. As discussed above, on quarter-ends, when non-U.S. dealers pulled back from the market to reduce the size of their balance sheets for financial reporting, the facility offered a backstop to eligible MMFs to place their excess cash. In the absence of the facility, withdrawal of dealers from the market on calendar days would be inconvenient for their lenders. This dynamic could in turn affect trading relationships and induce changes in dealers' trading strategies to lock in funding on and around quarter-end days as MMF funding could potentially shift away from these dealers. In the next section, we turn to the question of whether these dynamics forced non-U.S. dealers to pay a premium to keep their trading relationships stable with their cash lenders.

6. Bargaining Power in Trading Relationships

Having shown that changes in the monetary policy framework (inception of the RRP facility) and changes in the regulatory framework (implementation of the Basel III leverage ratio) reduced overall

MMF cash lending in the triparty repo market and reduced borrowing demand from some dealers on quarter-end days, we now investigate how these shocks may have affected the bargaining power of MMFs and dealers in their trading relationships.

Trading relationships in the triparty repo market are important due to their over-the-counter nature, that is, lenders and borrowers seek each other out to negotiate prices every day. First, we show that by providing an alternative investment option, the RRP facility increased the bargaining power of eligible MMFs over their dealer borrowers with whom they have strong relationships. Second, we show that, while the cost of window dressing increased for dealers trading with eligible funds after the inception of the RRP facility, this was not the case for dealers trading with ineligible funds.

6.1 Empirical Framework

We test for changes in MMFs' bargaining power after the inception of the RRP facility in two steps. First, we examine whether the volatility of the rates in the triparty market declined for eligible MMFs in comparison with ineligible MMFs. Klee, Senyuz, and Yoldas (2019) show that the RRP facility led to stronger co-movement of overnight money market rates and reduced volatility of the repo rate. In light of these results, we look into the potential effect of the RRP facility on rate volatility to assess if the facility had anchored the rates charged by eligible MMFs in the private market. Second, we examine whether the overall decline in triparty repo lending by MMFs, shown in Table 2, was due to eligible MMFs pulling back from lending.

We then analyze the effects of Basel III implementation on bargaining power dynamics, which took place after the inception of the RRP facility. In particular, we analyze whether bargaining power shifted towards window-dressing dealers post-Basel III as their MMF lenders needed to place their cash elsewhere on financial reporting days.

We construct two measures of trading relationship strength for each lender and borrower reflecting the intensive and extensive margin of the importance of their relationship (see Maggio, Kermani, and Song 2017). To capture the importance of the borrower (lender) to the lender's (borrower's) business—the intensive margin—we

define two daily variables for each borrower-lender (i, j) pair. Borrower's share of the lender's business is given by

$$(Share\ of\ Business)_{i,j,t} = \frac{(Volume)_{i,j,t}}{(Total\ Volume\ by\ i(j))_t}. \quad (4)$$

To capture the importance of the borrower (lender) to the lender's (borrower's) frequency of trading—the extensive margin—we define the *Frequency of Trading* between a borrower i and a lender j on day t, as follows:

$$(Frequency\ of\ Trading)_{i,j,t} = \frac{(Number\ of\ Transactions)_{i,j,t}}{(Total\ Number\ of\ Transactions\ by\ i(j))_t}. \quad (5)$$

To test for changes in MMF bargaining power after the RRP facility started, we estimate Equation (6) for the volume-weighted average repo rate, $r_{i,j,t}$, and also for its 30-day rolling standard deviation as a proxy for rate volatility, which is $\sigma(r)_{i,j,t}$.[16]

$$\begin{aligned} r_{i,j,t} = {} & \beta_0 + \beta_{1i,j}\,(Rel\ Strength)_{i,j,t} \times 1(t = RRP2) \\ & + \beta_{2i,j}\,(Rel\ Strength)_{i,j,t} + \theta_{1i,j} + \phi_t \\ & + \delta_{1i,t-1} + \delta_{2j,t-1} + \epsilon_{i,j,t}, \end{aligned} \quad (6)$$

where *Rel Strength* is a vector capturing the relationship strength measures described above. β_1 is our coefficient of interest and shows how the reliance of dealers on MMF funding changed their rate for repo financing after the inception of the RRP facility.[17] We also include relationship fixed effects, $\theta_{1i,j}$, daily time fixed effects ϕ_t, and the borrower and lender control variables, $\delta_{1i,t-1}$ and $\delta_{2j,t-1}$, respectively, as defined in Section 3.1. Borrower (dealer) controls include

[16] Prior to August 22, 2014, given our Tuesday snapshot data we calculate the standard deviation by using the rate over the last four Tuesdays.

[17] We consider December 23, 2013 (that is, RRP2), as the start date of the facility because eligible funds did not reduce their lending until after individual bid amounts increased as of this date, as demonstrated in Table 2.

last quarter's $STFD$ and $Total\ Assets$. Lender (MMF) level controls are last month's AUM, Treasury repo outstanding, and Treasury securities held. Standard errors are clustered at the relationship level.

To test for potential changes in bargaining power after the implementation of Basel III, we estimate Equation (7) for the volume-weighted average repo rate, $r_{i,j,t}$ between borrower i and lender j on day t from January 2, 2013 to August 1, 2016.[18]

$$\begin{aligned} r_{i,j,t} = {} & \beta_0 + \beta_1 r_{i,j,t-1} + \theta_1 D_{1t} + \theta_{1i,j} \left(D_{1t} \times (Rel\ Strength)_{i,j,t} \right) \\ & + \theta_{2i,j} \left(Rel\ Strength \right)_{i,j,t} + \psi_{i,j} + \phi_t \\ & + \delta_{1i,t-1} + \delta_{2j,t-1} + \epsilon_{i,j,t}, \end{aligned} \tag{7}$$

where D_{1t} is a 3×1 vector including calendar-day indicators of one day prior to a quarter-end, the quarter-end, and one day after the quarter-end. Positive and significant coefficients in $\theta_{1i,j}$ would suggest that dealers that depend on their lenders pay higher rates on financial reporting days. We also include relationship fixed effects, $\psi_{i,j}$, and daily time fixed effects ϕ_t. The borrower and lender controls, as defined in Section 3.1, are reflected by $\delta_{1i,t-1}$ and $\delta_{2j,t-1}$, respectively. Standard errors are clustered at the relationship level.

6.2 Results

Table 4 presents the estimation results from Equation (6) using the volume-weighted average rate. We do not identify any significant and consistent effect of trading relationship strength on the level of the repo rate. This result is likely due to the anchoring effect of the RRP, as shown by Klee, Senyuz, and Yoldas (2019). However, if the facility anchored repo rates, we should observe a reduction in rate volatility after the facility was introduced. To explore this possibility, we estimate the same regression using the volatility of the repo rate as the dependent variable. Results are summarized in Table 5.

[18]Mid-June 2014 reflects the approximate implementation date for Basel III. Table A.1 in Appendix A shows that European dealers significantly increased their window dressing after the implementation of Basel III, not after its announcement.

Table 4. Effect of Trading Relationships on Repo Pricing

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Lender's Share of Business × RRP2	0.003**	–0.001		
	(1.98)	(–0.35)		
Dealer's Share of Business × RRP2	0.001	0.007		
	(0.31)	(0.41)		
Lender's Freq. × RRP2			0.001	–0.002
			(0.39)	(–0.81)
Dealer's Freq. × RRP2			–0.007***	0.025
			(–2.76)	(1.08)
Lender's Share of Business	–0.002	0.004		
	(–1.18)	(1.55)		
Dealer's Share of Business	0.000	–0.016		
	(0.07)	(–0.91)		
Lender's Freq. of Trading			–0.002	0.004
			(–1.09)	(1.62)
Dealer's Freq. of Trading			0.007**	–0.046**
			(2.40)	(–2.20)
Rate (–1)	0.235***	–0.008*	0.236***	–0.008*
	(9.10)	(–1.72)	(9.11)	(–1.72)
Controls	Yes	Yes	Yes	Yes
Observations	37,560	65,220	37,560	65,220
R^2	0.9922	0.4558	0.9922	0.4558

Note: This table presents the results of the panel regression shown in Equation (6) except where the dependent variable is the triparty rate charged between dealer i and MMF j. We include all foreign and U.S. dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. RRP2 is equal to 0 until December 23, 2013, and 1 thereafter. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table 5. Effect of Trading Relationships on Repo Volatility

	Eligible MMF (1)	Ineligible MMF (2)	Eligible MMF (3)	Ineligible MMF (4)
Lender's Share of Business × RRP2	0.005	–0.007		
	(1.35)	(–1.33)		
Dealer's Share of Business × RRP2	–0.010***	–0.014		
	(–2.96)	(–0.61)		
Lender's Freq. × RRP2			0.010*	–0.002
			(1.96)	(–0.44)
Dealer's Freq. × RRP2			–0.013***	–0.017
			(–2.90)	(–0.42)
Lender's Share of Business	–0.007*	0.003		
	(–1.95)	(0.71)		
Dealer's Share of Business	0.009***	0.003		
	(2.74)	(0.11)		
Lender's Freq. of Trading			–0.011**	0.002
			(–2.37)	(0.49)
Dealer's Freq. of Trading			0.012**	–0.059
			(2.51)	(–0.87)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Relationship FE	Yes	Yes	Yes	Yes
Observations	37,560	65,219	37,560	65,219
R^2	0.6780	0.3806	0.6782	0.3808

Note: This table presents the results of the panel regression shown in Equation (6). The dependent variable is the rolling standard deviation of the triparty repo rate between dealer i and MMF j. We include all foreign and U.S. dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. RRP2 is equal to 0 until December 23, 2013, and 1 thereafter. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

As shown in columns 1 and 3, a one-standard-deviation increase in dealers' *Share of Business* and *Frequency of Trading* is associated with a 1 basis point decline in the volatility of repo rates received by eligible MMFs after the RRP facility started. This finding, which is consistent with Klee, Senyuz, and Yoldas (2019), reflects that the facility offering rate anchored rates that eligible funds charged when lending. Insignificant coefficients on the lender side indicate that the dependence of the lender on the borrower does not play a role in the stability of the repo rate. Further, as shown in columns 2 and 4, there is no statistically significant change to the volatility of repo rates received by ineligible MMFs from their dealer borrowers regardless of relationship strength after the RRP facility, which is consistent with the fact that these funds do not have access to the facility.[19]

Table 6 shows the estimation results from Equation (7). As shown in columns 1 and 3, a one-standard-deviation increase in dealers' *Share of Business* or *Frequency of Trading* is associated with higher rates charged for dealers on financial reporting days when borrowing from eligible MMFs. Specifically, dealers dependent on eligible MMF business pay about half a basis point more for funding on the day before the quarter-end than on other days, reflecting the cost of window dressing. The RRP facility allowed eligible MMFs to maintain their bargaining power over their dealer borrowers with whom they had strong relationships, regardless of their window-dressing activity. As shown in columns 2 and 4, there is no significant change in the rates that ineligible MMFs charged their dealer borrowers on or around quarter-end.

Table 7 presents the results when the dependent variable in Equation (7) is replaced with the log of transaction volume between dealer i and MMF j on day t. As shown in columns 1 and 3, a one-standard-deviation increase in dealer's *Share of Business* and dealer's *Frequency of Business* is associated with about 90 percent and 150 percent increase in repo volumes on quarter-ends in comparison to other days, suggesting that dealers dependent on eligible MMF business were unable to window dress as effectively as with

[19] Although some coefficients of interest appear larger in magnitude in columns 2 and 4 than those in columns 1 and 3, we are unable reject the null hypothesis that they are equal to zero.

Table 6. Effect of Trading Relationships on Repo Pricing during Quarter-ends

	Eligible MMF (1)	Ineligible MMF (2)	Eligible MMF (3)	Ineligible MMF (4)
Dealer's Share of Business × Quarter-end (–1)	0.005**	–0.002		
	(2.59)	(–0.18)		
Dealer's Share of Business × Quarter-end	0.008	–0.005		
	(1.17)	(–0.44)		
Dealer's Share of Business × Quarter-end (+1)	–0.003	0.005		
	(–0.91)	(1.30)		
Dealer's Freq. × Quarter-end (–1)			0.007***	0.004
			(2.77)	(0.32)
Dealer's Freq. × Quarter-end			0.008	–0.008
			(1.15)	(–0.65)
Dealer's Freq. × Quarter-end (+1)			–0.004	0.003
			(–0.95)	(0.75)
Dealer's Share of Business	–0.001	–0.012***		
	(–0.72)	(–2.89)		
Dealer's Freq. of Trading			–0.002	–0.027*
			(–0.81)	(–1.78)
Rate (–1)	0.254***	–0.009**	0.254***	–0.009**
	(9.25)	(–2.10)	(9.25)	(–2.11)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Relationship FE	Yes	Yes	Yes	Yes
Observations	32,331	56,128	32,331	56,128
R^2	0.9922	0.4303	0.9922	0.4303

Note: This table presents the results of the panel regression shown in Equation (7). The dependent variable is the triparty repo rate charged by MMF j to dealer i. We include all foreign and U.S. dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table 7. Effect of Trading Relationships on Repo Volumes during Quarter-ends

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Dealer's Share of Business × Quarter-end (–1)	–0.272	–0.684		
	(–1.29)	(–0.82)		
Dealer's Share of Business × Quarter-end	0.897**	0.421		
	(2.31)	(1.29)		
Dealer's Share of Business × Quarter-end (+1)	0.309	–0.498		
	(0.99)	(–1.57)		
Dealer's Freq. × Quarter-end (–1)			–0.277*	–1.569**
			(–1.83)	(–2.19)
Dealer's Freq. × Quarter-end			1.520***	1.796***
			(3.53)	(5.35)
Dealer's Freq. × Quarter-end (+1)			0.897**	0.797***
			(2.26)	(2.90)
Dealer's Share of Business	3.262***	3.421***		
	(6.71)	(5.22)		
Dealer's Freq. of Trading			1.567***	1.445***
			(4.42)	(4.66)
Volume (–1)	0.489***	0.632***	0.598***	0.695***
	(16.03)	(28.80)	(21.52)	(37.71)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Relationship FE	Yes	Yes	Yes	Yes
Observations	32,331	56,128	32,331	56,128
R^2	0.8040	0.9126	0.7693	0.9049

Note: This table presents the results of the panel regression shown in Equation (7), except the dependent variable is the log of the volume borrowed by dealer i from MMF j. We include all foreign and U.S. dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

other dealers. Further, results in column 4 suggest that ineligible MMFs were able to maintain some bargaining power over the dealers that are reliant on their business, but only through the extensive margin, as indicated by the positive and significant coefficient on dealer's *Frequency of Business* on quarter-ends.

In summary, we find that, even after the implementation of Basel III, which strengthened window-dressing incentives for certain dealers, eligible MMF bargaining power increased in triparty repo trading. Those dealers that were reliant on eligible MMF lending were unable to window dress as much as other dealers, and ended up paying higher rates for funding on financial reporting days.

One caveat to these results is that they do not take into account the formation and termination of relationships, and that the eligibility of MMFs to the RRP was not random. In Section B.1 of Appendix B, we show results that test the robustness of Tables 5, 6, and 7. We condition on trading relationships between dealers and MMFs that existed prior to the RRP and persisted through the end of our sample. The results are presented in Tables A.3, A.4, and A.5. Our results are consistent with those presented in Section 6.2, suggesting that trading relationship formations and terminations are not the factors driving our results. In Section B.2 of Appendix B, we explore the possibility that observable characteristics of eligible MMFs, rather than their eligibility to the RRP, might be driving our results. In Tables A.6, A.7, and A.8, we compare eligible funds to ineligible funds that could have been eligible had they submitted the paperwork to participate at the RRP. All funds in the robustness analysis had an AUM of at least $5 billion for six consecutive months, which was the most stringent condition of RRP eligibility. Our analysis shows that RRP eligibility, and not observable characteristics of eligible MMFs, drives our main results.

Finally, in Appendix C we present some additional results exploring how the network between dealers and MMFs changed after the inception of the RRP facility. We find evidence that the strength of relationships between non-U.S. dealers and ineligible MMFs weakened during the post-Basel III period and, at the same time, non-U.S. dealers became more reliant on eligible MMF funding. These results are presented in Tables A.9 and A.10. We argue that this shift in the network was likely a contributing factor for window dressing to become more expensive for non-U.S. dealers.

7. Implications for MMFs' Balance Sheet Management

Financial intermediaries, such as dealers, typically finance their portfolio of high-quality but long-term assets in the repo market. To meet their short-term funding needs, dealers rely on MMFs as their primary cash lenders in the repo market. If dealers were unable to fund their assets in the repo market on a consistent basis, resulting liquidity mismatch has the potential to disrupt financial stability.

In this section, we analyze how the inception of the RRP facility as a backstop for eligible MMFs may have affected MMFs' investment strategies. The data on MMF balance sheets come from the SEC N-MFP filings at the end of each month from January 31, 2013 through July 31, 2016 for all eligible and ineligible MMFs in our data set.

Tables 8 and 9 summarize the regression results for eligible and ineligible MMFs, respectively. Control variables include the MMFs' assets under management and standard errors are clustered at the fund level. In each table, column 1 shows the effect of changes in Treasury repo activity (which includes RRP takeup) on changes in repo activity backed by other collateral including asset-backed commercial paper (ABCP), commercial paper (CP), and corporate debt on MMF j's balance sheet; column 2 shows the effect of changes in Treasury repo activity on the market value of all other items, excluding repo, on MMFs' balance sheet; and column 3 shows the effect of changes in Treasury repo activity on the weighted-average maturity (WAM) of all other items, excluding repo, on MMFs' balance sheet.

Table 8 presents some evidence of substitution between Treasury repo and repo backed by other collateral for eligible funds after the inception of the RRP facility. A one-standard-deviation increase in the change in Treasury repo is associated with an 18 percentage point decline in repo backed by other collateral (column 1). The evidence is much stronger for substitution between Treasury repo and other items on the balance sheet. We observe an almost 40 percentage point decline in all other items, excluding repo, in response to a one-standard-deviation increase in Treasury repo (column 2). These results translate to an average of $152 million and $2.9 billion decline per fund in repo backed by other collateral and in other items on the balance sheet, respectively. Eligible MMFs appeared to have preferred Treasury repo over repo backed by other collateral that

Table 8. Effect of RRP Facility on Eligible MMF Holdings

	Chg. Other Repo (1)	Chg. All Other (2)	Chg. WAM All Other (3)
Chg. Tsy. Repo × RRP2	–0.183**	–0.397***	
	(–2.06)	(–4.37)	
Chg. Tsy. Repo	0.080	–0.394***	
	(1.33)	(–3.47)	
Tsy. Repo × RRP2			–0.111*
			(–1.80)
Tsy. Repo			0.089
			(1.10)
Chg. All Other			0.490***
			(2.95)
Controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
MMF FE	Yes	Yes	Yes
Observations	1,124	1,124	1,124
R^2	0.1618	0.5629	0.1529

Note: This table presents the results of a panel regression for eligible MMFs. The dependent variable in column 1 is the change in repo outstanding backed by all collateral other than Treasury securities. The dependent variable in column 2 is the change in the market value of all other items on MMF j's balance sheet excluding repo. The dependent variable in column 3 is the change in the weighted-average maturity (WAM) of all other items, excluding repo, on MMF j's balance sheet. The monthly sample run uses month-end snapshots from N-MFP filings from January 30, 2013 to July 31, 2016, and is obtained from the SEC. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the fund level.

might be considered more risky, and also over investing in ABCP, CP, and corporate debt (components of "all other"). Further, there is some evidence of eligible MMFs reducing their WAMs by about 11 percentage points, as indicated by the negative coefficient on the interaction term that is statistically significant at the 10 percent level.

Table 9 shows the results on changes in the balance sheets of ineligible funds after the RRP facility. As expected, since they could not access the facility, ineligible funds did not change their balance sheets

Table 9. Effect of RRP Facility on Ineligible MMF Holdings

	Chg. Other Repo (1)	Chg. All Other (2)	Chg. WAM All Other (3)
Chg. Tsy. Repo × RRP2	–0.251	–0.645*	
	(–1.15)	(–1.95)	
Chg. Tsy. Repo	0.031	–0.127	
	(0.21)	(–0.48)	
Tsy. Repo × RRP2			–0.090***
			(–3.39)
Tsy. Repo			0.197**
			(2.06)
Chg. All Other			–0.050
			(–0.76)
Controls	Yes	Yes	Yes
Time FE	Yes	Yes	Yes
MMF FE	Yes	Yes	Yes
Observations	1,999	1,999	1,979
R^2	0.1489	0.3031	0.0415

Note: This table presents the results of a panel regression for ineligible MMFs. The dependent variable in column 1 is the change in repo outstanding backed by all collateral other than Treasury securities. The dependent variable in column 2 is the change in the market value of all other items on MMF j's balance sheet excluding repo. The dependent variable in column 3 is the change in the weighted-average maturity (WAM) of all other items, excluding repo, on MMF j's balance sheet. The monthly sample run uses month-end snapshots from N-MFP filings from January 30, 2013 to July 31, 2016, and is obtained from the SEC. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the fund level.

materially after its inception. However, as shown in column 3, ineligible MMFs shortened their WAMs by 9 percentage points on average, which corresponds to about a decline of six days to accommodate outflows. While there is also some evidence of WAM shortening for eligible funds during this period, much stronger evidence for ineligible MMFs may reflect their potential hedging behavior against risks of not having the RRP facility as a backstop. Their inability to tap the RRP facility when they needed to place their excess

cash overnight may have induced them to rely on investments with shorter duration, other things equal.

Our results suggest that the inception of the RRP facility influenced the way MMFs manage their balance sheets. With the changing incentives, eligible MMFs shifted some of their investments to safer alternatives such as Treasury repo. While the eligible funds benefited from having the RRP facility as a backstop, balance sheet management of ineligible funds remained largely unchanged, except for a slight shortening of their WAMs, which may reflect a desire to hedge against increased outflows.

8. Concluding Remarks

We analyze the effects of monetary and regulatory policy on trading dynamics in the U.S. repo market. On the supply side, we find that the introduction of the RRP facility led to a 16 percent reduction in cash lending by MMFs eligible to transact with the Fed in the repo market. On the demand side, we find that after the Basel III leverage ratio implementation, window dressing by European dealers intensified notably with total reduction in their repo borrowing on quarter-ends reaching 30 percent. Putting these two shocks together, we show that bargaining power of MMFs increased after the inception of the RRP facility. For those dealers reliant on eligible MMF funding, window dressing became more expensive than for dealers less reliant on MMF funding. However, the average rates they paid remained stable given the anchoring effect of the RRP facility. Our results highlight the importance of MMF-dealer relationships and their effects on bargaining power dynamics in the triparty repo market.

We also find evidence that the changing trading dynamics in the repo market following the RRP facility influenced the way MMFs manage their balance sheets. While eligible MMFs shifted the composition of their balance sheets towards Treasury repo and away from repo backed by other collateral, ineligible funds reduced their WAMs modestly. These findings highlight the financial stability implications of the RRP facility through its effects on MMF balance sheet management.

Appendix A. Basel III Capital Regulations and Repo Borrowing

In this section, we describe our empirical framework to analyze the effects of Basel III capital regulations on triparty repo borrowing on regulatory reporting days. For this analysis, we use a separate confidential data set of daily overnight repo borrowing by each dealer in the triparty market, from July 1, 2008, to August 1, 2016, which were reported by two custodian banks—BNYM and JPM—to FRBNY.[20]

Basel III rules that required repo positions to be included in the leverage exposure calculations were announced in the United States in June/July 2013, which coincided with the timing of leverage ratio requirements being transposed to local rules in Europe. Although full compliance with the new regulations was not mandated until January 2018, banks started to adjust their strategies earlier in order to signal that they are well positioned to meet regulatory targets by the compliance deadlines. On January 1, 2015, dealers began reporting the new leverage ratios to the public, including three quarters of historical data, making 2014:Q2 the first quarter-end entering into the calculations. Our sensitivity analysis across alternative quarter-end dates also confirmed that 2014:Q2 was associated with the largest statistically significant dealer response on a quarter-end.

To measure the extent of window dressing by dealer groups from different regional jurisdictions and their response to the implementation of Basel III leverage ratio requirements, we estimate the following time-series regression for daily repo borrowing by European and U.S. dealers from July 1, 2008, to August 1, 2016.

$$\begin{aligned} RB_t = {} & \beta_0 + \beta_1 D_{1t} + \beta_2 D_{2t} + \phi_1 RB_{t-1} \\ & + \theta_1 \big(\textit{Quarter-end} \times \textit{Announced}\big)_t \\ & + \theta_2 \big(\textit{Quarter-end} \times \textit{Implemented}\big)_t + \epsilon_t, \end{aligned} \tag{8}$$

where RB_t is the log of aggregate repo borrowing by dealers on day t. *Announced* equals 1 after the details of Basel III regulations were announced on June 15, 2013 and turns 0 after the implementation takes place. *Implemented* takes the value 0 before June 15,

[20] We exclude data on interdealer GCF segment and RRP trades with the Fed.

Table A.1. Overnight Repo Borrowing by Dealers on Calendar Days and Effects of Regulations

	European Overnight Borrowing (1)	**U.S. Overnight Borrowing (2)**
Quarter-end × Announced	–0.021	0.030
	(–0.59)	(1.14)
Quarter-end × Implemented	–0.193***	0.066
	(–5.84)	(1.62)
Quarter-end (–5)	–0.005	0.016
	(–0.71)	(1.51)
Quarter-end (–4)	–0.033**	–0.014
	(–2.45)	(–1.03)
Quarter-end (–3)	–0.013	–0.003
	(–0.96)	(–0.35)
Quarter-end (–2)	–0.051***	–0.008
	(–5.75)	(–1.34)
Quarter-end (–1)	–0.043***	0.031***
	(–4.13)	(4.07)
Quarter-end	–0.107***	0.037
	(–4.46)	(1.46)
Quarter-end (+1)	0.155***	–0.047***
	(5.43)	(–3.23)
Quarter-end (+2)	0.022***	0.004
	(2.82)	(0.33)
Quarter-end (+3)	–0.008	–0.010
	(–0.84)	(–1.24)
Quarter-end (+4)	–0.000	–0.010
	(–0.05)	(–0.85)
Quarter-end (+5)	0.019**	0.014
	(1.96)	(1.61)
Overnight Borrowing (–1)	0.887***	0.957***
	(54.14)	(98.62)
Observations	1,056	1,056
R^2	0.977	0.981

Note: This table presents the results of time-series regressions for the log of overnight repo borrowing by European and U.S. dealers, in columns 1 and 2, respectively. *Announced* equals 1 after the details of Basel III regulations were announced on June 15, 2013 and turns 0 when the implementation of the new rules takes place. *Implemented* takes the value 0 before June 15, 2014, and 1 after this date. The daily sample runs from January 2, 2011, to August 1, 2016. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. *t*-ratios are reported in parentheses and are calculated using robust standard errors.

2014, and 1 after this date. Since these models are estimated at the daily frequency, we switch on the indicator variables in the middle of the month to capture dynamics of the first quarter-end that follows. *Quarter-end* is an indicator variable that take the value 1 on quarter-ends, and 0 on other days. D_{1t} is a 12×1 vector that includes calendar-day indicators of five days prior to a quarter-end, the quarter-end, five days after the quarter-end, and *Month-end*. D_{2t} is a 2×1 vector that includes the *Announced* and *Implemented* indicators.

Our specification has two interaction terms to capture the change in repo borrowing with respect to our dates of interest: θ_1 measures the change in borrowing on quarter-ends after the announcement; θ_2 captures the quarter-end change after the implementation. If European dealers were incentivized to contract their balance sheet on financial reporting days because of less stringent implementation of the Basel III leverage ratio, we expect θ_1 and θ_2 to be negative and significant for European dealers and insignificant for U.S. dealers whose calculations are based on daily averages. Since repo borrowing exhibits substantial persistence, we also include its first lag in the model to account for autocorrelation. We calculate standard errors robust to heteroskedasticity and winsorize all continuous variables at the 1 percent level, although our results are robust to keeping the outliers.

Appendix B. Robustness Analysis

B.1 Trading Relationships

Since short-term funding is difficult to replace, dealers tend to trade with the same MMFs every day. Table B.1 illustrates the persistence of these relationships. There are 1,101 dealer-MMF pairs in the data from January 1, 2013 to August 1, 2016, with an average number of days in a trading relationship equal to 307. A dealer-MMF pair is considered to be in a relationship if the pair trades for at least two trading days. Conditional on dealer-MMF pairs that had a trading relationship from September 23, 2013, to August 1, 2016, we identify 623 dealer-MMF pairs with an average number of days in a relationship equal to 319 days. These statistics suggest that relationships that terminated before the inception of the RRP were just as persistent as relationships that existed well after the inception of the RRP.

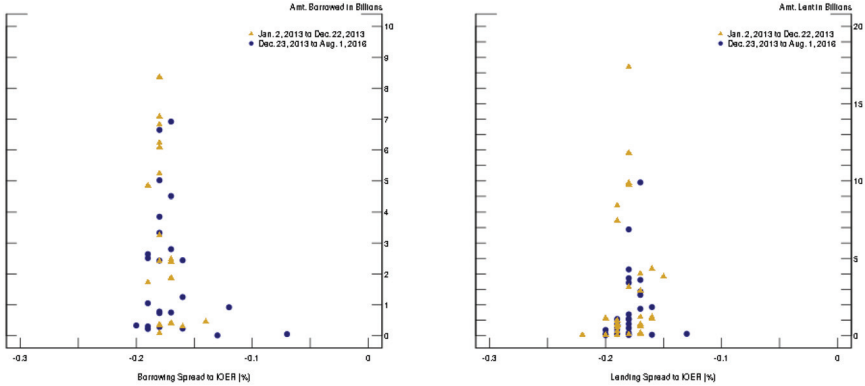
Table B.1. Summary Statistics of Trading Relationships

	Statistic
No. Dealers	23
No. MMFs	288
No. Dealer-MMF Pairs	1,101
No. Dealer-MMF Pairs, Conditional on Existing before RRP	623
Avg. No. Days in Relationship	307
Avg. No. Days in Relationship, Conditional on Existing before RRP	319
Avg. Share of MMF's Business	0.39
Avg. Share of Dealer's Business	0.39
Avg. Count of MMF's Business	0.08
Avg. Count of Dealer's Business	0.07

Figure B.1 shows the transacted volumes and the associated rates by borrowers (dealers) and lenders (MMFs), respectively, from January 2, 2013, to December 22, 2013 (triangles) and from December 23, 2013, to August 1, 2016 (dots) for overnight GC repo. Each triangle (dot) represents a borrower or lender. We observe that dealers borrow roughly the same amount each day from the same MMF lenders, with very similar transaction volumes before and after the RRP facility. Accordingly, Figure B.1 illustrates the inelasticity of demand and supply for short-term funding in the triparty repo market.

Tables B.2, B.3, and B.4 display robustness analysis for the results in Tables 5, 6, and 7, respectively, which are not conditional on existing trading relationships before the RRP facility. We reestimate Equations (6) and (7) conditioning on trading relationships that existed before the RRP facility. Table B.2 displays the regression results of Equation (6) conditioning on existing relationships. As shown in columns 1 and 3, all else equal, a one-standard-deviation increase in *Dealer's Share of Business* and *Dealer's Frequency of Trading* is associated with about a 1 basis point decline in the standard deviation of repo rates received by eligible MMFs after the inception of the RRP facility. Further, as shown in columns 2 and 4, there is no change to the standard deviation of repo rates received by ineligible MMFs from their dealer borrowers regardless of relationship strength after the RRP facility. Table B.3 displays results from

Figure B.1. Trading Dynamics in Triparty Repo



Note: This figure displays the borrowing (left) and lending (right) spread against total volume for each borrower (and lender) in the overnight GC triparty repo market across two date ranges: before the inception of the RRP between January 2 and December 22, 2013 (triangles); and after the inception of the RRP between December 23, 2013 and August 1, 2016 (circles). The borrowing spread is defined as the volume-weighted average interest rate a borrower paid minus IOER. The lending spread is defined as the volume-weighted average interest rate a lender gained minus IOER. The data are confidential transaction data and are from the Federal Reserve Bank of New York.

Equation (7) conditional on existing relationships before the RRP. Columns 1 and 3 show that a one-standard-deviation in dealers' *Share of Business* or *Frequency of Trading* is associated with higher borrowing rates from eligible MMFs on financial reporting days. As shown in columns 2 and 4, there is no change in the rates that ineligible MMFs charged their dealer borrowers that window dress with whom they have strong relationships. Finally, Table B.4 shows the results where the dependent variable in Equation (7) is replaced with the log of transaction volume between dealer i and MMF j on day t, for those dealer-MMF relationships that existed before the RRP facility. As shown in columns 1 and 3, a one-standard-deviation increase in *Dealer's Share of Business* and *Dealer's Frequency of Business* is associated with about 106 percent and 170 percent *increase* in repo volumes on quarter-ends in comparison to other days. All these results are consistent with our main results shown in Tables 5, 6, and 7.

Table B.2. Effect of Existing Trading Relationships on Repo Volatility

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Lender's Share of Business × RRP2	0.006	–0.004		
	(1.58)	(–0.84)		
Dealer's Share of Business × RRP2	–0.010***	–0.013		
	(–2.90)	(–0.53)		
Lender's Freq. × RRP2			0.011**	0.001
			(2.22)	(0.13)
Dealer's Freq. × RRP2			–0.011**	–0.028
			(–2.45)	(–0.72)
Lender's Share of Business	–0.006*	0.005		
	(–1.77)	(1.09)		
Dealer's Share of Business	0.008**	–0.001		
	(2.32)	(–0.03)		
Lender's Freq. of Trading			–0.010**	0.003
			(–2.11)	(0.72)
Dealer's Freq. of Trading			0.012**	0.004
			(2.36)	(0.16)
Controls	Yes	Yes	Yes	Yes
Observations	28,693	41,455	28,693	41,455
R^2	0.6725	0.2487	0.6730	0.2488

Note: This table presents the results of the panel regression shown in Equation (6) but conditions on trading relationships that existed prior to September 22, 2013. The dependent variable is the rolling standard deviation of the overnight GC triparty repo rate between dealer i and MMF j. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. RRP2 is equal to 0 until December 23, 2013, and 1 thereafter. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the dealer-MMF level.

Table B.3. Effect of Existing Trading Relationships on Repo Pricing during Quarter-ends

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Dealer's Share of Business × Quarter-end (–1)	0.005**	0.005		
	(2.50)	(0.71)		
Dealer's Share of Business × Quarter-end	0.003	–0.011		
	(0.49)	(–1.14)		
Dealer's Share of Business × Quarter-end (+1)	–0.004	0.010		
	(–0.97)	(1.56)		
Dealer's Freq. × Quarter-end (–1)			0.006***	–0.001
			(2.87)	(–0.07)
Dealer's Freq. × Quarter-end			0.003	–0.015
			(0.45)	(–1.57)
Dealer's Freq. × Quarter-end (+1)			–0.004	0.005
			(–1.06)	(0.91)
Dealer's Share of Business	–0.002	–0.014**		
	(–1.14)	(–2.49)		
Dealer's Freq. of Trading			0.000	–0.016
			(0.09)	(–0.86)
Rate (–1)	0.248***	0.030	0.248***	0.030
	(7.68)	(0.92)	(7.68)	(0.92)
Controls	Yes	Yes	Yes	Yes
Observations	23,722	33,165	23,722	33,165
R^2	0.9920	0.8267	0.9920	0.8267

Note: This table presents the results of the panel regression shown in Equation (7) but conditions on trading relationships that existed prior to September 22, 2013. The dependent variable is the overnight GC triparty repo rate charged by MMF j to dealer i. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table B.4. Effect of Existing Trading Relationships on Repo Volumes during Quarter-ends

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Dealer's Share of Business × Quarter-end (–1)	–0.387	0.412		
	(–1.66)	(0.55)		
Dealer's Share of Business × Quarter-end	1.061**	0.810		
	(2.46)	(1.27)		
Dealer's Share of Business × Quarter-end (+1)	0.276	–0.604		
	(0.78)	(–1.06)		
Dealer's Freq. × Quarter-end (–1)			–0.337**	–0.367
			(–2.14)	(–0.53)
Dealer's Freq. × Quarter-end			1.695***	2.319***
			(3.50)	(4.38)
Dealer's Freq. × Quarter-end (+1)			0.887*	1.060**
			(1.89)	(2.32)
Dealer's Share of Business	3.427***	3.953***		
	(6.18)	(4.08)		
Dealer's Freq. of Trading			1.603***	1.770***
			(4.26)	(3.96)
Volume (–1)	0.454***	0.621***	0.559***	0.698***
	(15.13)	(20.31)	(20.25)	(27.44)
Controls	Yes	Yes	Yes	Yes
Observations	23,722	33,165	23,722	33,165
R^2	0.7813	0.8947	0.7426	0.8828

Note: This table presents the results of the panel regression shown in Equation (7), except the dependent variable is the log of overnight GC borrowing by dealer i from MMF j, and conditions on trading relationships that existed prior to September 22, 2013. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

To sum up, trading relationships between dealers and MMFs are long term and persistent, with very stable transacted volumes. Relationship formations and terminations do not seem to affect MMF bargaining power in this market.

B.2 MMF Characteristics

We perform robustness tests of the results discussed in Section 6.2 to explore potential bias in comparison of the bargaining power of eligible versus ineligible MMFs, given that eligible MMFs could choose to become RRP counterparties. Although the process of applying to the Federal Reserve Bank of New York to become an RRP counterparty was not arduous, a major criterion included having AUM of at least $5 billion over the last consecutive six months.

Table B.5 shows the results from Equation (6). In columns 2 and 4 we now condition on funds that could have been eligible to use the RRP facility, as they are similar to eligible MMFs in that they have AUM above $5 billion. We observe no changes to the standard deviation of repo rates received by funds that met the eligibility requirements regardless of relationship strength after the inception of the facility, consistent with the results reported in Table 5, suggesting that fund characteristics were not driving the standard deviation of repo rates. Table B.6 shows the estimation results from Equation (7) where columns 2 and 4 condition on funds that met the eligibility requirements but did not become eligible. Again, no change is observed in the rates charged by MMFs, consistent with the results in Table 6, providing further evidence that observable characteristics of eligible funds were not driving the repo rates. Finally, Table B.7 shows the results where the dependent variable in Equation (7) is replaced with the log of transaction volume between dealer i and MMF j on day t. As shown in columns 2 and 4, we observe fewer changes in repo volumes on quarter-ends in comparison to other days for funds that met the eligibility requirements in comparison to eligible MMFs. These results are consistent with our main results shown in Table 7, and provide further evidence that it was the presence of the RRP facility that affected the bargaining power of eligible MMFs.

Table B.5. Effect of Trading Relationships on Repo Pricing Volatility Comparing Eligible MMFs to Funds that Met RRP Requirements

	Eligible MMF (1)	**Meets Req. (2)**	**Eligible MMF (3)**	**Meets Req. (4)**
Lender's Share of Business × RRP2	0.005	–0.017		
	(1.35)	(–1.58)		
Dealer's Share of Business × RRP2	–0.010***	–0.044		
	(–2.96)	(–0.89)		
Lender's Freq. × RRP2			0.010*	–0.007
			(1.96)	(–1.01)
Dealer's Freq. × RRP2			–0.013***	–0.106
			(–2.90)	(–1.08)
Lender's Share of Business	–0.007*	0.008		
	(–1.95)	(1.37)		
Dealer's Share of Business	0.009***	0.043		
	(2.74)	(0.79)		
Lender's Freq. of Trading			–0.011**	0.002
			(–2.37)	(0.19)
Dealer's Freq. of Trading			0.012**	0.064
			(2.51)	(0.73)
Controls	Yes	Yes	Yes	Yes
Observations	37,560	17,571	37,560	17,571
R^2	0.6780	0.1989	0.6782	0.1987

Note: This table presents the results of the panel regression shown in Equation (6). Columns 1 and 3 display the results for eligible MMFs. Columns 2 and 4 display the results for MMFs that met the eligibility requirements to approach the RRP. The dependent variable is the rolling standard deviation of the overnight GC triparty repo rate between dealer i and MMF j. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. RRP2 is equal to 0 until December 23, 2013, and 1 thereafter. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table B.6. Effect of Trading Relationships on Repo Pricing during Quarter-ends Comparing Eligible MMFs to Funds that Met RRP Requirements

	Eligible MMF (1)	**Meets Req. (2)**	**Eligible MMF (3)**	**Meets Req. (4)**
Dealer's Share of Business × Quarter-end (–1)	0.005**	0.027**		
	(2.59)	(2.47)		
Dealer's Share of Business × Quarter-end	0.008	0.012		
	(1.17)	(1.33)		
Dealer's Share of Business × Quarter-end (+1)	–0.003	0.013		
	(–0.91)	(1.24)		
Dealer's Freq. × Quarter-end (–1)			0.007***	0.006
			(2.77)	(0.14)
Dealer's Freq. × Quarter-end			0.008	0.010
			(1.15)	(1.18)
Dealer's Freq. × Quarter-end (+1)			–0.004	0.012
			(–0.95)	(1.25)
Dealer's Share of Business	–0.001	–0.012		
	(–0.72)	(–1.30)		
Dealer's Freq. of Trading			–0.002	–0.033
			(–0.81)	(–1.28)
Rate (–1)	0.254***	0.016	0.254***	0.016
	(9.25)	(0.80)	(9.25)	(0.80)
Controls	Yes	Yes	Yes	Yes
Observations	32,331	14,713	32,331	14,713
R^2	0.9922	0.7421	0.9922	0.7421

Note: This table presents the results of the panel regression shown in Equation (7). Columns 1 and 3 display the results for eligible MMFs. Columns 2 and 4 display the results for MMFs that met the eligibility requirements to approach the RRP. The dependent variable is the overnight GC triparty repo rate charged by MMF j to dealer i. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table B.7. Effect of Trading Relationships on Repo Volumes during Quarter-ends Comparing Eligible MMFs to Funds that Met RRP Requirements

	Eligible MMF (1)	Meets Req. (2)	Eligible MMF (3)	Meets Req. (4)
Dealer's Share of Business × Quarter-end (–1)	–0.272	0.876		
	(–1.29)	(0.80)		
Dealer's Share of Business × Quarter-end	0.897**	–0.156		
	(2.31)	(–0.20)		
Dealer's Share of Business × Quarter-end (+1)	0.309	–0.938		
	(0.99)	(–0.93)		
Dealer's Freq. × Quarter-end (–1)			–0.277*	0.768
			(–1.83)	(0.70)
Dealer's Freq. × Quarter-end			1.520***	2.042***
			(3.53)	(4.14)
Dealer's Freq. × Quarter-end (+1)			0.897**	1.026
			(2.26)	(1.46)
Dealer's Share of Business	3.262***	4.635***		
	(6.71)	(3.87)		
Dealer's Freq. of Trading			1.567***	2.471***
			(4.42)	(3.95)
Volume (–1)	0.489***	0.561***	0.598***	0.685***
	(16.03)	(13.51)	(21.52)	(20.20)
Controls	Yes	Yes	Yes	Yes
Observations	32,331	14,713	32,331	14,713
R^2	0.8040	0.8096	0.7693	0.7706

Note: This table presents the results of the panel regression shown in Equation (7), where the dependent variable is replaced to be the log of overnight GC volume borrowed by dealer i from MMF j. Columns 2 and 4 display the results for ineligible MMFs that met the eligibility requirements to approach the RRP. We include all foreign (European, U.K., Japanese, Canadian) and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Appendix C. Triparty Repo Network Structure

We present additional results on the effects of changing monetary (RRP facility) and regulatory policy (Basel III leverage ratio) changes on the triparty repo network structure. Given the salience of these changes, we should expect changes to the network structure of the triparty repo market. To assess these changes, we estimate the following equation for the two trading relationship measures defined in Equations (4) and (5). For dealer i and MMF j on day t from January 2, 2013 to August 1, 2016, $y_{i,j,t} = (\textit{Share of Business, Frequency of Trading})_{i,j,t}$.

$$\begin{aligned} y_{i,j,t} = \beta_0 &+ \beta_1 1(i = Foreign)_i \times 1(t = RRP1)_t \\ &+ \beta_2 1(i = Foreign)_i \times 1(t = RRP2)_t \\ &+ \beta_3 1(i = Foreign)_i \times 1(t = Implemented)_t \\ &+ \theta_{1i,j} + \phi_t + \delta_{1i,t-1} + \delta_{2j,t-1} + \epsilon_{i,j,t} \end{aligned} \tag{9}$$

$1(i = \textit{Foreign})_i$ equals 1 if dealer i is a foreign dealer, and 0 otherwise; $1(t = \textit{RRP1})_t$ equals 1 between September 23, 2013 and December 23, 2013, and 0 otherwise; $1(t = \textit{RRP2})_t$ equals 1 between December 23, 2013 and June 15, 2014, and 0 otherwise; $1(t = \textit{Implemented})_t$ equals 1 after June 15, 2014, and 0 otherwise, labeling the implementation date of Basel III regulations. We include relationship fixed effects, $\theta_{1_{i,j}}$, daily time fixed effects ϕ_t, and the borrower and lender control variables, $\delta_{1i,t-1}$ and $\delta_{2j,t-1}$, respectively, as defined in Section 3.1. Borrower (dealer) controls include last quarter's *STFD* and *Total Assets*. Lender (MMF) level controls are last month's AUM, Treasury repo outstanding, and Treasury securities held. Standard errors are clustered at the relationship level.

Table C.1 presents the results from the estimation of Equation (9) from the perspective of MMF *j*. Columns 1 and 2 show the results for $\textit{Share of Business}_{i,j,t}$ and columns 3 and 4 show the results for $\textit{Frequency of Trading}_{i,j,t}$. From column 2 we see that ineligible MMFs lent 2.1 percentage points less to foreign dealers after Basel III was implemented. In the post-Basel III era, relationships between ineligible MMFs and foreign dealers weakened.

Table C.1. Effect of RRP on Relationship Strength: MMF Perspective

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Foreign × RRP1	0.006	–0.004	–0.005	0.001
	(0.63)	(–0.56)	(–0.71)	(0.11)
Foreign × RRP2	0.003	–0.002	–0.005	–0.003
	(0.23)	(–0.27)	(–0.42)	(–0.58)
Foreign × Implemented	0.009	–0.021***	–0.004	–0.010
	(0.87)	(–2.59)	(–0.59)	(–1.48)
Lender's Share of Business (–1)	0.655***	0.740***		
	(28.14)	(35.05)		
Lender's Freq.			0.649***	0.757***
			(16.76)	(30.03)
Controls	Yes	Yes	Yes	Yes
Observations	37,560	65,220	37,560	65,220
R^2	0.7998	0.8425	0.8372	0.8826

Note: *Foreign* equals 1 if dealer i is a foreign dealer, and 0 otherwise. RRP1 equals 1 between September 23, 2013 and December 23, 2013. RRP2 equals 1 between December 23, 2013 and June 15, 2014. *Implemented* equals 1 after June 15, 2014 to capture the Basel III implementation period. We include all foreign and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table C.2. Effect of RRP on Relationship Strength: Dealer Perspective

	Eligible MMF (1)	**Ineligible MMF (2)**	**Eligible MMF (3)**	**Ineligible MMF (4)**
Foreign × RRP1	0.006	0.000	0.004	0.002
	(0.67)	(0.05)	(0.87)	(1.27)
Foreign × RRP2	0.014*	0.004*	0.006	0.007**
	(1.66)	(1.76)	(1.20)	(2.54)
Foreign. × Implemented	0.023***	0.003	0.010**	0.007***
	(2.61)	(0.78)	(2.21)	(2.79)
Dealer's Share of Business (–1)	0.713***	0.680***		
	(22.03)	(14.91)		
Dealer's Freq.			0.656***	0.603***
			(21.23)	(10.70)
Controls	Yes	Yes	Yes	Yes
Observations	37,560	65,220	37,560	65,220
R^2	0.8755	0.8280	0.9222	0.8566

Note: *Foreign* equals 1 if dealer i is a foreign dealer, and 0 otherwise. RRP1 equals 1 between September 23, 2013 and December 23, 2013. RRP2 equals 1 between December 23, 2013 and June 15, 2014. *Implemented* equals 1 after June 15, 2014 to reflect the approximate implementation date of Basel III regulations. We include all foreign and domestic dealers. The daily sample runs from January 2, 2013, to August 1, 2016, and is obtained from FRBNY. ***, **, and * indicate statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. t-ratios are reported in parentheses. Standard errors are clustered at the relationship level.

Table C.2 presents the results from the estimation of Equation (9) from the perspective of dealer i. Columns 1 and 2 show the results for *Share of Business*$_{i,j,t}$ and columns 3 and 4 show the results for *Frequency of Trading*$_{i,j,t}$. From column 1, we observe some evidence of foreign dealers concentrating their borrowing from eligible MMFs. The reliance of foreign dealers on eligible MMF funding in the post-Basel III era was likely a contributing factor of why window dressing became more expensive for non-U.S. dealers.

References

Adrian, T., M. Fleming, J. Goldberg, M. Lewis, F. M. Natalucci, and J. J. Wu. 2013. "Dealer Balance Sheet Capacity and Market Liquidity during the 2013 Selloff in Fixed Income Markets." FEDS Notes, Board of Governors of the Federal Reserve System.

Adrian, T., and H. S. Shin. 2010. "Liquidity and Leverage." *Journal of Financial Intermediation* 19 (3): 418–37.

———. 2011. "Financial Intermediary Balance Sheet Management." Staff Report No. 532, Federal Reserve Bank of New York.

Afonso, G., A. Kovner, and A. Schoar. 2014. "Trading Partners in the Interbank Lending Market." Staff Report No. 620, Federal Reserve Bank of New York.

Agarwal, V., G. D. Gay, and L. Ling. 2014. "Window Dressing in Mutual Funds." *Review of Financial Studies* 27 (11): 3133–70.

Allen, L., and A. Saunders. 1992. "Bank Window Dressing: Theory and Evidence." *Journal of Banking and Finance* 16 (3): 585–623.

Anderson, A., and J. Kandrac. 2018. "Monetary Policy Implementation and Financial Vulnerability: Evidence from the Overnight Reverse Repurchase Facility." *Review of Financial Studies* 31 (9): 3643–86.

Babus, A., and T.-W. Hu. 2017. "Endogenous Intermediation in Over-the-Counter Markets." *Journal of Financial Economics* 125 (1): 200–215.

Bharath, S. T., S. Dahiya, A. Saunders, and A. Srinivasan. 2011. "Lending Relationships and Loan Contract Terms." *Review of Financial Studies* 24 (4): 1141–1203.

Chernenko, S., and A. Sunderam. 2014. "Frictions in Shadow Banking: Evidence from the Lending Behavior of Money Market Funds." *Review of Financial Studies* 27 (6): 1717–50.

Cocco, J. F., F. J. Gomes, and N. C. Martins. 2009. "Lending Relationships in the Interbank Market." *Journal of Financial Intermediation* 18 (1): 24–48.

Copeland, A., A. Martin, and M. Walker. 2014. "Repo Runs: Evidence from the Tri-Party Repo Market." *Journal of Finance* 69 (6): 2343–80.

Dass, N., and M. Massa. 2011. "The Impact of a Strong Bank-Firm Relationship on the Borrowing Firm." *Review of Financial Studies* 24 (4): 1204–60.

Duffie, D., N. Gârleanu, and L. H. Pedersen. 2005. "Over-the-Counter Markets." *Econometrica* 73 (6): 1815–47.

———. 2007. "Valuation in Over-the-Counter Markets." *Review of Financial Studies* 20 (6): 1865–1900.

Elliott, G., T. J. Rothenberg, and J. H. Stock. 1996. "Efficient Tests for an Autoregressive Unit Root." *Econometrica* 64 (4): 813–36.

Frost, J., L. Logan, A. Martin, P. McCabe, F. Natalucci, and J. Remache. 2015. "Overnight RRP Operations as a Monetary Policy Tool: Some Design Considerations." Finance and Economics Discussion Series No. 2015-010, Board of Governors of the Federal Reserve System.

Gofman, M. 2017. "Efficiency and Stability of a Financial Architecture with Too-Interconnected-to-Fail Institutions." *Journal of Financial Economics* 124 (1): 113–46.

Gorton, G., and A. Metrick. 2012. "Securitized Banking and the Run on Repo." *Journal of Financial Economics* 104 (3): 425–51.

Han, S., and K. Nikolaou. 2016. "Trading Relationships in the OTC Market for Secured Claims: Evidence from Triparty Repos." Finance and Economics Discussion Series No. 2016-064, Board of Governors of the Federal Reserve System.

Hansen, B. E. 2001. "The New Econometrics of Structural Change: Dating Breaks in U.S. Labour Productivity" *Journal of Economic Perspectives* 15 (4): 117–28.

Hendershott, T., D. Li, D. Livdan, and N. Schurhoff. 2016. "Relationship Trading in OTC Markets." Paper presented at the American Finance Association 2016 Meeting, San Francisco, CA, January 3–5.

Ihrig, J. E., G. C. Weinbach, and E. E. Meade. 2015. "Rewriting Monetary Policy 101: What's the Fed's Preferred Post-Crisis

Approach to Raising Interest Rates?" *Journal of Economic Perspectives* 29 (4): 177–98.

Klee, E., Z. Senyuz, and E. Yoldas. 2019. "Effects of Changing Monetary and Regulatory Policy on Money Markets." *International Journal of Central Banking* 15 (4, October): 165–205.

Krishnamurthy, A., S. Nagel, and D. Orlov. 2014. "Sizing Up Repo." *Journal of Finance* 69 (6): 2381–2417.

Lakonishok, J., A. Shleifer, R. Thaler, and R. Vishny. 1991. "Window Dressing by Pension Fund Managers." *American Economic Review: Papers and Proceedings* 81 (May): 227–31.

Li, D., and N. Schürhoff. 2019. "Dealer Networks." *Journal of Finance* 74 (1): 91–144.

Macchiavelli, M., and X. A. Zhou. 2019. "Funding Liquidity and Market Liquidity: The Broker-Dealer Perspective." http://dx.doi.org/10.2139/ssrn.3311786.

Maggio, M. D., F. Franzoni, A. Kermani, and C. Sommavilla. 2019. "The Relevance of Broker Networks for Information Diffusion in the Stock Market." *Journal of Financial Economics* 134 (2): 419–46.

Maggio, M. D., A. Kermani, and Z. Song. 2017. "The Value of Trading Relations in Turbulent Times." *Journal of Financial Economics* 124 (2): 266–84.

Martin, A., D. Skeie, and E.-L. von Thadden. 2014. "Repo Runs." *Review of Financial Studies* 27 (4): 957–89.

Munyan, B. 2015. "Regulatory Arbitrage in Repo Markets." Working Paper No. 15-22, Office of Financial Research.

Neklyudov, A. 2019. "Bid-Ask Spreads and the Over-the-Counter Interdealer Markets: Core and Peripheral Dealers." *Review of Economic Dynamics* 33 (July): 57–84.

Ng, S., and P. Perron. 2001. "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power." *Econometrica* 69 (6): 1519–54.

Perron, P. 1989. "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis." *Econometrica* 57 (6): 1361–1401.

Sias, R. W., and L. T. Starks. 1997. "Institutions and Individuals at the Turn-of-the-Year." *Journal of Finance* 52 (4): 1543–62.