Window-Dressing and the Fed's RRP Facility in the Repo Market*

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Abstract

We analyze repurchase agreement (repo) markets in the wake of Basel III regulations and the reverse repo facility of the Federal Reserve (Fed). Using a proprietary data set of repo transactions, we find that differences in regional implementation of these regulations intensified window-dressing by European dealers who reduced their borrowing by 17% on financial reporting days. Consequently, money funds cut their repo lending by half and lent to the Fed instead when European dealers withdraw. In a difference-in-differences setting, we quantify these effects on relationships, and find that funds ineligible for Fed trades lent 15% less to European dealers compared with eligible funds.

Keywords: repo, Basel III regulations, window-dressing, monetary policy, Federal Reserve, reverse repo (RRP) facility.

JEL Classification: C32, E43, E52

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1 Introduction

The repurchase agreement (repo) segment of the U.S. money market is a critical source of short-term funding for a wide range of financial intermediaries. By offering loans that are secured against high-quality liquid assets, the repo market facilitates efficient allocation of capital in the financial system. Since the global financial crisis of 2007 to 2009, dynamics in this market have changed considerably in the wake of new financial regulations, and the changing monetary policy framework of the Federal Reserve (Fed).

We identify two plausibly exogenous shocks that affected incentives of primary participants in the repo market: the introduction of the Basel III regulatory framework which affected the cash demand in the market, and the inception of the Fed's reverse repo (RRP) facility which affected the cash supply. We quantify the effects of these demand and supply shocks on behaviors of major repo borrowers (dealers) and lenders (money market mutual funds), respectively, and then examine potential changes in their trading relationships.

The Basel III framework has been the building block of the new regulatory landscape. The new regulations imposed constraints on dealers, the primary cash borrowers in the repo market, and affected their balance sheet management. Prior to the implementation of the Basel III, non-U.S. dealers had already been reducing the size of their balance sheets on financial reporting days, as they were permitted to submit ratios based on quarter-end snapshots of their balance sheets, a phenomenon commonly referred to as window-dressing (see, for example, Allen and Saunders (1992), Lakonishok et al. (1991), Sias and Starks (1997), and Agarwal et al. (2014) among others). Unlike non-U.S. dealers, U.S. dealers had no incentive to engage in window-dressing as they were reporting ratios based on daily averages (see Munyan (2015)). Capital reforms released by the Basel Committee on Banking Supervision introduced a leverage ratio, which requires banks to hold Tier 1 capital

equivalent to at least 3% of their leverage exposure calculated using their on- and off-balance sheet assets. Thus, Basel III regulatory framework imposed formal constraints on European dealers, who were not previously subject to them, and for U.S. dealers, who were subject only to less restrictive requirements.[1]

On the monetary policy front, the Fed, as well as other major central banks, responded to the crisis using a variety of unconventional measures when short-term interest rates hit their effective lower bound. In particular, the Fed developed several liquidity facilities and conducted large-scale asset purchases (LSAPs) which expanded its balance sheet and prompted it to develop new tools to control interest rates. In October 2008, the Fed started paying interest on reserves (IOR) which became its primary monetary policy tool. About five years later, the overnight RRP facility was introduced as a supplementary tool to enhance rate control. By offering a secured lending rate through overnight RRP operations which are available to a broad set of counterparties, the Fed effectively set a soft floor for overnight funding rates (see Klee et al. (2016) for an analysis of the effects of the RRP facility on overnight funding rates).

The evolving regulatory and monetary policy environments have implications for trading strategies and financial reporting conventions of dealers who are the main cash borrowers in the repo market, as well as money market mutual funds (also referred to as money funds, or MMFs), their primary cash lenders. In this paper, we first study how dealer groups that are subject to different constraints responded to the new regulations, and we then analyze how the Fed's RRP facility affected MMF lending by offering an alternative investment option to those funds that are eligible to participate in the RRP operations. Once we quantify the

[1]European dealers refer to dealers in the European Union, and in the United Kingdom.

effects of these demand and supply shocks, we turn to examining their effects on trading relationships in the repo market.

One cannot easily separate potential window-dressing activity from typical demand supply dynamics in the repo market, in the absence of an exogenous shock. The implementation of the Basel III regulatory framework was a plausibly exogenous demand shock to repo borrowing that allows us to identify the specific dealer response on certain days. The regional differences in the implementation of leverage ratio requirements incentivize European dealers to contract their balance sheet on financial reporting days to appear more attractive to their regulators and investors. Since their calculated leverage ratios are not affected by their repo activity on other days, European dealers have the flexibility to expand borrowing on non-quarter-ends days unlike their U.S. counterparts.

We analyze the effect of European dealers window-dressing activity on their ability to obtain funding considering the Basel III framework as a demand shock to trading relationships. The regional implementation differences of Basel III regulations allow us to determine our control and treatment groups: the U.S. and European dealers, respectively. To examine changes in relationships that are unrelated to the risk profile of the trading parties we rely on the Fed's reverse repo (RRP) facility. The inception of the overnight RRP facility was a plausibly exogenous supply shock to the repo market because it reduced the cash supply by providing an alternative investment vehicle to counterparties that can trade with the Fed. The overnight RRP has been offered to a broad set of financial institutions, including MMFs, who have been the main cash lenders in the repo market. We examine the behavior of MMFs that are eligible to lend to the Fed via the RRP (eligible MMFs) to those MMFs that are not (ineligible MMFs). The Basel III regulatory framework, and the inception of the RRP

which affected suply and demand in the repo market, respectively, provide a unique setting to study changing relationship dynamics in this market.

Using a proprietary data set of daily repo borrowing in the triparty repo market, we first estimate time-series models for repo borrowing by European and U.S. dealers to measure potential changes in their activity on and around financial reporting days—in particular, their response to the Basel III regulations. We find that European dealers were reducing their borrowing by a total of 12% five days leading up to quarter-ends, and an additional 10% on the quarter-ends. After the financial reporting day, European dealers were reversing this strategy by increasing their borrowing by 11% immediately on the two days following the quarter-end. While these dynamics are strongly pronounced for European dealers, we do not see any significant pattern for U.S. dealers at or around quarter-ends, on average.

In terms of the response to the implementation of the Basel III leverage ratio, we find that European dealers started to reduce their repo borrowing by an additional 7.6%, for a total of almost 18% on the quarter-end date. This amounts to a total reduction of 30% in their repo borrowing around financial reporting days. In addition, we find some evidence of U.S. dealers increasing their presence in the market on those days when European dealers withdraw in the post-Basel III period. We also provide further insight into dealer balance sheet management by analyzing overnight and term trades separately from 2011 onwards. In the post Basel III period, we find that window-dressing has mainly been driven by adjustments to overnight trades rather than term trades.

Next, we turn to the supply side to identify the effects of the RRP facility in the repo market. We show that the RRP facility was a shock to the cash supply in the repo market, which led to a 16% reduction in eligible MMF lending. We estimate that, on quarter-ends, eligible MMF lending to dealers declined almost by half, as MMFs increased their usage

at the RRP facility. On the contrary, we do not find any significant response by ineligible MMFs on these days, as they still need to invest their cash in the private market on days when European dealers withdraw for financial reporting purposes.

Putting the demand and supply components together, we then analyze MMF dealer relationships in the repo market using a proprietary transaction-level data set of daily repo activity. In a difference-in-differences (DID) setting, we exploit the regional differences in the implementation of Basel III leverage ratio requirements to define our treatment group (European dealers) and control group (U.S. dealers). The RRP facility allows us to distinguish eligible and ineligible MMFs and measure the effects of the RRP on trading relationships. We find significant differences in the behavior of MMFs that are not eligible to transact with the Fed via the RRP facility compared with those that are. Ineligible MMFs lent 15% less to European dealers that withdrew from the repo market on financial reporting days compared with U.S. dealers, suggesting that it was inconvenient for ineligible MMFs to trade with dealers that window-dress. Moreover, eligible MMFs were more likely to lend to European dealers since they had access to the RRP which provided a convenient alternative investment opportunity when certain borrowers disappeared from the market.

Our analysis on window-dressing is related to Munyan (2015), who finds for the pre-Basel III period that non-U.S. banks contracted their balance sheets on financial reporting days to appear safer and less levered. Using an extended data set, we show that the Basel III implementation created a new incentive for European dealers to window-dress their balance sheets. We document that window-dressing by European dealers has intensified mainly through adjustments of overnight trades around financial reporting days. Furthermore, our results suggest that in the absence of the RRP facility, window-dressing activity would likely increase the funding costs of European dealers.

Our work contributes to the growing literature on repo market dynamics. Adrian and Shin (2011) 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, Gorton and Metrick (2012), Copeland et al. (2014), and Krishnamurthy et al. (2014) analyze the role of repo markets during the global financial crisis. As for the effects of the Fed's RRP facility on the repo market, Anderson and Kandrac (2016) and Han and Nikolaou (2016) find evidence of crowding out of private repo activity.

Finally, our paper is also related to the literature on trading relationships in various financial markets. Han and Nikolaou (2016) analyze relationship structures in the repo market and show that shocks are absorbed better by trading parties with strong relationships. Afonso et al. (2014) and Cocco et al. (2009) document evidence for the crucial role of trading relationships for access to credit in the interbank market. Several studies suggest evidence for the importance of trading relationships in other markets as well (see, for example, Hendershott et al. (2016) and DiMaggio et al. (forthcoming) for fixed-income trading; Chernenko and Sunderam (2014) for money market fund lending; and Dass and Massa (2011), and Bharath et al. (2011) on the nature of bank firm relationships.)

The rest of the paper is organized as follows. Section 2 provides background information on the mechanics of the repo market, reviews the new Basel III regulations, and the Fed's changing monetary policy implementation. Section 3 provides detailed information on the two proprietary data sets of repo transactions. Section 4 documents window-dressing by certain dealers in response to Basel III regulations. Section 5 quantifies the effects of the RRP facility on MMF lending. Section 6 describes the DID setting to analyze changing trading relationships in the repo market, and presents the results. Section 7 concludes.

2 The Repo Market and the Changing Policy Environment

2.1 Review of Repo Market Mechanics

A repo is a secured loan contract that is collateralized by a security. A repo transaction facilitates the sale and future repurchase of the security that serves as collateral between the two parties: (1) the borrower who owns a security and seeks cash and (2) 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. Over the course of the transaction, the cash borrower retains the ownership of the security. 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. From the cash borrowers perspective, this transaction is called a repo, and from the cash lender's perspective, it is called a reverse repo.[2]

The market value of the securities used as collateral in a repo transaction typically exceeds the value of the cash lent. The difference between the market value of the security and the cash lent in a repo transaction against that collateral is referred to as a haircut. Haircuts help protect the cash lenders against a decline in the market price of the security used as collateral. In the event of a default, the ownership of the collateral switches to the cash lender who can sell it to recover the loan amount.

A general collateral (GC) repo is the most common type of repo transaction involving securities that meet the predetermined eligibility criteria to be accepted as collateral. Also

[2]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.

known as Fedwire-eligible collateral, this class of assets typically consists of U.S. Treasury securities, agency debt and agency mortgage-backed securities (MBS).

The repo market can be divided into two broad segments: the bilateral market and the triparty market. In the bilateral market, lenders and borrowers usually interact directly to negotiate the terms and settle the trade. Hedge funds and other investment managers are the primary borrowers in the bilateral market who seek funding from dealers or money funds. In the triparty market, lenders and borrowers use the services of a third party to act as a custodian, providing operational efficiencies over the course of the transaction. In the current triparty repo platform, two clearing banks—Bank of New York Mellon (BONY) and J.P. Morgan (JPM)—provide custodial services such as collateral valuation and trade settlement in repo transactions. The clearing banks are responsible for the movement of cash and collateral over the course of the repo trade. In the event of a default, the clearing bank would transfer the collateral to the lender's custodial account.

The overall daily triparty repo market volume, including both overnight and term trades, is estimated to be around $1.8 trillion, with more than $1.5 trillion of the volume consisting of transactions involving GC. The primary cash lenders in the repo market are mutual funds, government-sponsored enterprises (GSEs), and other banks. Figure 1 shows the monthly overnight GC triparty volumes by lender types. As shown by the blue shaded bars, mutual funds account for about 80% of cash lending in the overnight GC repo market. The repo market is also an important investment platform for GSEs, which constitute about 10% of the total monthly volume. All other types of cash lenders account for the remaining 10% of the volume. On the demand side, main cash borrowers include banks and securities dealers. Figure shows monthly triparty repo borrowing by U.S. dealers and European dealers since

the beginning of 2011. We observe parallel borrowing activity by two groups suggesting that, on average, they have been responding to the same market factors.

The triparty GC repo market also includes the overnight RRP operations by the Fed and transactions in the General Collateral Finance (GCF) segments. The Fed participates in the triparty repo platform by conducting temporary open market operations. These RRP operations as well as other design features of the Fed's new monetary policy framework are described in the next section. GCF is a blind-brokered, interdealer repo platform, which provides funding for dealers that may not have sustainable access to cash in the broader triparty market. Figure 3 shows an organizational diagram of the triparty GC repo market. This platform consists of the triparty transactions in the broad market where BONY and JPM serve as the custodian banks (70% of volume), transactions in the interdealer GCF market (15% of volume), and transactions with the Fed via the RRP facility (15% of volume).[3]

2.2 Window-Dressing and the New Regulatory Framework

On financial reporting days, banks 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 window-dressing strategy dates back to the 1800s, and may take place in a variety of ways (see, for example, Allen and Saunders (1992)). Prior to the crisis, the key motivation of engaging in window-dressing was to improve the profitability measures, such as return on assets of a financial institution, mainly for public reporting purposes. However, during and after the global financial crisis, against the backdrop of the more stringent regulatory environment, financial intermediaries started focusing on the capital and liquidity measures for regulatory reporting instead.

[3]These percentages are the approximate shares of each segment from 2014 to 2016. GCF volume significantly dropped since mid-2016 when Fixed Income Clearing Corporation suspended its clearing service.

Dealers used to operate with substantial leverage as they were not subject to leverage limits prior to the crisis. Adrian and Shin (2010) and Adrian and Shin (2011) show that dealers adjust the size of their balance sheets mainly through short-term borrowing in the repo market, and dealer leverage is pro-cyclical. When regulators responded to the crisis with requirements of higher quality assets and lower leverage, dealers were prompted to reevaluate their risk management practices and adjust their balance sheet management. The decline in leverage is an indication that dealer risk-taking has moderated since the crisis (see for example, Adrian et al. (2013)).

Among the new regulations, the Basel III capital and liquidity reforms that significantly changed the regulatory landscape for financial intermediaries are of particular importance. Pre-Basel III leverage requirements for U.S. dealers excluded all off-balance sheet items, hence they were less restrictive. Basel III capital reforms introduced a leverage ratio, which requires banks to hold Tier 1 capital equal to 3% 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 has been different among the dealers based on their jurisdictions. In the United States, the Basel III leverage ratio was implemented as the Supplementary Leverage Ratio (SLR), and 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.[4] This difference in regional implementation of the leverage ratio created different incentives for European versus U.S. dealers. 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 financial reporting dates and expand it on non-reporting days. While the European banks are incentivized to

[4]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.

engage in window-dressing, U.S. dealers which report leverage ratios calculated on a daily basis do not have any reason to contract their balance sheets on month- or quarter-ends.

The Basel III regulatory framework 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 for a longer horizon. Although the U.S. rule was more stringent than the Basel III standard, all banks are required to be compliant with LCR on a daily basis. As a result, there is no reason for such liquidity measures to affect quarter-end dynamics of the two dealer groups separately.[5]

Another regulation that may have incentivized some foreign banks to engage in quarter-end deleveraging has been the Dodd-Frank Wall Street Reform and Consumer Protection Act's requirements for foreign banking organizations (FBOs). The act required FBOs with $50 billion or more in U.S. non-branch/non-agency assets as of July 1, 2015, to establish an intermediate holding company. For the largest FBOs, the threshold to comply with the SLR was $250 billion, which likely incentivized some dealers to reduce their repo supply to get below the threshold by the compliance date. Reporting of non-branch assets by FBOs to determine applicability of the new rule started on June 30, 2014. This rule reportedly incentivized some deleveraging on quarter-ends from June 2014 to June 2015 for FBOs close to the threshold. Although some reduction in repo activity on quarter-ends may have taken place due to the IHC rule, there are no FBOs in our data set with total assets below $250 billion.

Finally, a change to deposit insurance made by the Federal Deposit Insurance Corporation (FDIC) in April 2011 had some effect on aggregate repo activity. The FDIC expanded its

[5]LCR requirements may have affected aggregate repo activity for collateral other than Treasury securities since these transactions reduce a bank's LCR.

deposit insurance assessment base to include reserve balances of banks held at the Fed. This change made short-term funding more costly for FDIC-insured U.S. banks relative to that of U.S. branches and agencies of foreign banks and created an incentive for U.S. banks to reduce their borrowing (Kreicher et al. (2013)). However, this change in the aggregate repo activity of U.S banks is not specific to financial reporting days and is unlikely to affect window-dressing by dealers.

2.3 Fed's RRP Facility

Historically, the Fed used to adjust the level of scarce reserve balances in the banking system through open market operations to control the level of the effective federal funds rate. During the global financial crisis and its aftermath, the Fed has increased the size of its balance sheet through several liquidity facilities and LSAPs. As a result of the expansion of the Fed's balance sheet, reserves in the financial system have reached unprecedented levels. In this environment of superabundant reserves, monetary policy implementation would no longer work in the conventional way.

The Fed made important changes to its operational framework following the height of the crisis in the fall of 2008.[6] In October 2008, the Fed started paying IOR to banks that have accounts at the Fed. Although the IOR became the primary tool of the new policy framework, it could not set an effective floor for the federal funds rate because of the fragmented structure in the federal funds market that emerged in the superabundant reserves environment. In September 2013, the Fed introduced the overnight RRP facility as a supplementary tool of its new policy framework to enhance monetary control. In normalization principles released one year later, the Fed indicated that it would move the federal funds rate into the target

[6]See Ihrig et al. (2015) for details of the Fed's monetary policy implementation framework during and after the crisis.

range primarily by adjusting the IOR and use an overnight RRP facility as a supplementary policy tool as needed to help control the federal funds rate.[7]

Overnight RRPs are offered to a broad set of financial institutions including nonbank institutions that are important cash lenders in the repo market, such as MMFs.[8] The Fed has been offering overnight RRPs on a daily basis at a preannounced offering rate. Through this facility, the Fed borrows cash from eligible counterparties in exchange for Treasury securities in its portfolio. These transactions take place with the agreement to repurchase the same security at a specified price at a specific time in the future.

The overnight RRP facility provides a convenient alternative investment vehicle for MMFs that compare the facility's offering rate with other rates in the market and determine whether to bid in the overnight RRP operation offered each day. This way, the offering rate at the facility should help establish a floor for overnight funding rates, as MMFs would be unwilling to lend in the market at any rate below the offering rate. Klee et al. (2016) show that the overnight RRP facility has been affecting repo market dynamics by setting a soft floor for overnight funding rates and reducing the repo rate volatility.

After the overnight RRP operations have started on September 23, 2013, takeup was very low in the first few months of testing, during which the facility parameters were modified frequently. Takeup increased significantly following an increase in the individual bid amount to $5 billion on December 23, 2013, and reached levels consistent with the average takeup since the inception of the facility.

Figure 4 shows the composition of participating counterparties at the overnight RRP operations since January 2014. MMFs have been the primary participants, accounting for

[7]Further details on monetary policy normalization are available on the Federal Reserve Board's website at http://www.federalreserve.gov/monetarypolicy/policy-normalization.htm.

[8]There are currently 158 RRP counterparties including MMFs, GSEs, primary dealers and other banks.

the majority of takeup at the facility. MMFs are the biggest cash lenders in the money market for overnight Treasury GC repo and view overnight RRP as a low-return low-risk investment compared with lending to dealers. When dealers withdraw from overnight funding markets on quarter-ends to contract their balance sheets for financial reporting purposes, the facility provides an alternative investment vehicle for their primary cash lenders, MMFs. 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.

Investment capacity at the facility proved to be an important factor affecting repo rates, especially on quarter-ends. On days leading up to the September 2014 quarter-end, the Fed introduced an overall cap of $300 billion on overnight RRP operations which led to a sharp drop in money market rates as cash lenders scrambled for alternative investments. In October 2014, the FOMC authorized a series of term RRPs spanning over the year-end to help address downward pressure on rates. These operations were conducted around quarter-ends to provide extra capacity to RRP counterparties by letting them invest their cash ahead of the quarter-end day. The term RRP operations enhanced rate control around quarter-ends suggesting that perceived investment capacity is important in determining the effectiveness of RRPs in supporting rates. [9]

Figure 5 shows the daily RRP takeup after the individual bid size increased to $5 billion on December 23, 2013.[10] Average daily volume was around $100 billion for our sample,

[9]The cap at the overnight RRP was lifted in December 2015 when the Fed announced the first rate hike in nine years, ending the zero lower bound period. There have been no term RRP operations spanning quarter-ends since that time. Currently, overnight RRP operations are limited only by the value of the Treasury securities in the Fed's open market portfolio that are available for these operations, which stand at around $2 trillion.

[10]Throughout the paper, we refer to RRP operations as the sum of overnight and term operations, since total capacity offered by the Fed is what matters for understanding MMF behavior.

which ends in August 2016. Seasonal spikes correspond to quarter-ends, when total RRP takeup hit record levels as borrowers reduce their demand for repo financing.

3 Data and Preliminary Analysis

3.1 TriParty Repo Dealer Borrowing Data

We consider transactions in the triparty market excluding the interdealer GCF segment, and RRP trades with the Fed. To measure the extent of window-dressing activity by dealers described earlier, we use a proprietary data set of daily repo borrowing by each dealer in the triparty market, which is available daily from July 1, 2008. These data are reported by two custodian banks—BONY and JPM—to the Federal Reserve Bank of New York (FRBNY). Beginning on January 2, 2011, the data set also includes information on the maturity of transactions, allowing us to also distinguish overnight activity from longer term trades. This information may provide further insight into dealer strategies around financial reporting days.[11] We end our sample on August 1, 2016.

Table 1 reports summary statistics for all collateral types used in triparty repo transactions from January 2, 2011 to August 1, 2016, the period for which we have the maturity breakdown of trades. Since 2011, the average daily volume in the triparty repo market has been around $1.3 trillion for GC (Treasury securities, agency debt and agency MBS) and around $300 billion for all other collateral (non-GC). U.S. Treasury securities account for nearly 40% of the total collateral pledged in the market, while the share of agency MBS is around 30%. About 60% of the total triparty repo volume corresponds to overnight activity in the triparty repo market.

[11] We exclude continuing trades which account for about 7% of the total triparty volume.

Figure 6 displays a time-series of triparty GC repo volumes (excluding the GCF and RRP segments), along with the non-GC volume for the longer sample, from July 1, 2008, to August 1, 2016. The average daily triparty repo volume for GC was around $1.8 trillion at the beginning of our sample in July 2008. At that point, prior to the bankruptcy of Lehman Brothers in the fall of 2008, the leverage of dealers had already been declining amid heightened risk aversion. After the Fed completed its first round of LSAPs in March 2010, repo activity generally trended up until the peak in mid-2012. The decline in repo activity after this date may be attributed to the release of proposals for more stringent Basel III regulatory requirements that increased balance sheet costs, and to the final round of LSAPs conducted by the Fed, which reduced the available supply of collateral in repo transactions. In addition, the persistent low rate environment as well as more conservative internal risk control measures likely contributed to lower repo volumes during this time. As of mid-2016, the daily triparty GC repo volume stood at around $1.4 trillion.

The transaction volume for non-GC repo substantially dropped in the fall of 2008 when strains in money markets became extreme. The drop in non-GC repo volume was steeper and faster than the drop in GC repo volume, likely reflecting the higher risk associated with the securities used as collateral in these transactions. Since mid-2009, non-GC repo volume has been pretty stable, with an average daily volume of about $250 billion.

Another observation from Figure 6 is that repo borrowing exhibits seasonality. There have been pronounced drops in the transaction volume around quarter-ends although the steepness and the sharpness of these drops vary over time. This seasonal pattern is due to the temporary adjustment of repo activity by certain dealers around financial reporting days.

3.2 Triparty Repo Transaction Data

To examine MMF dealer trading relationships, we use a second proprietary data set of daily triparty repo transactions for each lender borrower pair. These data are reported by BONY to the FRBNY, which acts as custodian for about 80% of trades in the triparty repo market. Although this transaction data set is available from August 1, 2012, we start our sample from January 2, 2013, to exclude the early stage of the data collection period.

Prior to August 22, 2014, BONY used to provide a Tuesday snapshot of all outstanding open trades, for which it acts as custodian in the triparty repo market. After this date, BONY started providing daily transaction-level data. Although we do not observe the exact dates when term transactions are conducted, we can identify the overnight trades from these reports. To merge Tuesday snapshots with the daily transaction data, we multiply the reported transaction volume on Tuesdays by the number of business days in that week to obtain an approximate weekly volume for each lender borrower pair. Accordingly, for the post August 22, 2014 period we sum all transactions for a given lender borrower pair at the weekly level.

Since our goal is to analyze MMF-dealer relationships, it is necessary to identify from among all MMF lenders in the data set those funds that are eligible to lend to the Fed via the RRP facility. However, identification of eligible lenders poses a challenge as lender names are not uniform throughout the data set. For example, there are frequent occurrences of different strings that refer to the same lender. Therefore, we manually match all appropriate lender strings to a single lender and identify specific lender types. Then, using the confidential monthly Securities and Exchange Commission Form N-MFP filings for MMFs, we identify MMFs at the fund level. It is crucial to identify MMFs at the fund level rather than at the complex level in order to parse out those funds that are eligible to lend to the Fed from those

that cannot. From N-MFP filings, we extract data on fund flows, assets under management (AUM), and overnight repo volume outstanding. To identify MMFs at the fund level, we merge the transaction-level data with three N-MFP filings from October 31, 2014; November 30, 2014; and December 31, 2014. A fund is considered matched if we match overnight repo volumes within a 1% error given collateral type.

Overall, we document that MMF lending corresponds to about 50% of the volume in the triparty repo market. We are able to match 245 MMFs and 16 dealers, which account for 82% of the transaction volume in this data set. We identify a total of 851 unique MMF-dealer relationships, and 46.220 transactions. As reported in Table 2, eligible and ineligible MMFs account for 42% and 58% of these transactions, respectively. European dealers participate in 55% of transactions while the U.S. dealers account for the remaining 45% of the transaction volume.

4 Window-Dressing and Cash Demand in the Repo Market

4.1 Identification Using the Basel III Regulatory Framework

As reviewed in Section 2.2, Basel III framework has been at the center of the changing regulatory landscape. In particular, the enhanced leverage ratio requirements created new incentives for banks and bank-affiliated dealers. We argue that regional differences in the implementation of the Basel III leverage ratio was a plausibly exogenous demand shock to dealers—the primary cash borrowers in the repo market—which allows us to identify specific dealer response to new regulations in the triparty repo market. Our identification strategy

stems from the differences in financial reporting of Basel III leverage ratios by European dealers in comparison with U.S. dealers. European dealers are incentivized to contract their balance sheets on financial reporting days to appear safer to their regulators, while U.S. dealers do not have such an incentive, as their calculations are based on daily averages of their balance sheet items. Therefore, U.S. and European dealers make up our control and treatment groups, respectively.

We consider several important dates in the Basel III regulation timeline to measure the extent of dealer response. Basel III capital rules that required repo positions to be included in the leverage exposure calculations were announced in the United States in June/July 2013. Leverage ratio requirements were transposed to local rules in Europe also by mid-2013. Therefore, we consider June 2013 as the announcement date of the leverage ratio requirements in both regions. Although full compliance with the new regulations is not mandated until January 1, 2018, banks usually start adjusting 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. This first public reporting using the new requirements included three quarters of historical data, making 2014:Q2 the first quarter-end entering into the calculations. Therefore, one may expect to see a significant response to the new leverage ratio requirements as early as 2014:Q2. We also conducted a sensitivity analysis across alternative quarter-end dates within this timeline, and confirmed that 2014:Q2 is associated with the largest statistically significant dealer response on a quarter-end.

4.2 Empirical Analysis

To quantify the extent of dealer window-dressing and its sensitivity to Basel III regulations, we estimate time-series regressions of aggregate daily repo borrowing by European and U.S. dealers for the full sample, from July 1, 2008, to August 1, 2016. Our specification is as follows:

$$\begin{aligned} RB_t = \beta_0 + \beta_1 D_{1t} + \beta_2 D_{2t} + \phi_1 RB_{t-1} \\ + \theta_1 \big(Quarter - end \times Announced\big)_t \\ + \theta_2 \big(Quarter - end \times Implemented\big)_t \\ + \theta_3 \big(Month - end \times Implemented\big)_t + \epsilon_t \end{aligned} \tag{1}$$

where RB_t is the log of aggregate repo borrowing by dealers in the triparty market at time t. *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.[12] $Quarter - end$ and $Month - end$ are the indicator variables that take the value 1 on those calendar days and 0 otherwise. $Month - end$ refers to those month-ends that are not also quarter-ends. 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-ends that are not quarter-ends. D_{2t} is a 2×1 vector that includes the *Announced* and $Implemented$ indicator variables.

Our specification has three interaction terms to measure the change in repo borrowing with respect to the dates of interest. θ_1 measures the change in repo borrowing on quarter-

[12] Since these models are estimated at the daily frequency, we switch on the indicator variables in the middle of the month in order to accurately capture dynamics of the first quarter-end that follows.

ends following the announcement date, while θ_2 captures the change on quarter-ends after the implementation date. Since quarterly reported ratios were calculated as the averages of month-end values for European dealers until October 2014—when the rule was amended to require only end-of-quarter reporting—we also include a third interaction term to measure potential month-end window-dressing. Thus, θ_3 reflects the change in repo borrowing on month-ends that are not quarter-ends after the implementation date. If European dealers were further incentivized to contract their balance sheet on financial reporting days because of Basel III regulations, we expect θ_1, θ_2, and θ_3 to be negative and significant for European dealers and near zero for U.S. dealers since their calculations are based on daily average values.

Finally, given that the repo borrowing exhibits substantial persistence, we include its first lag in the model to account for autocorrelation dynamics. We calculate robust standard errors and winsorize all continuous variables at the 1% level to avoid outliers that might bias the results.

Table 3 reports the estimation results from July 1, 2008, to August 1, 2016, for European and U.S. dealers in columns (1) and (2), respectively. First, we find that European dealers have been reducing their borrowing by about 12% five days leading up to quarter-ends, and an additional 9.8% on quarter-ends. The reduction in repo borrowing intensifies two days before the quarter-end. Following the financial reporting date, European dealers have been reversing this strategy, with a 11% increase in their total borrowing immediately on the two days following the quarter-end. While these dynamics are strongly pronounced for European dealers, we do not see any significant pattern for U.S. dealers at or around quarter-ends.

Second, we show that window-dressing activity by European dealers has intensified after the implementation of the Basel III leverage ratio regulations. European dealers further

reduced their repo borrowing by 7.6% on quarter-ends, for a total decline of 17.4% in one day after Basel III leverage ratio was implemented. This result implies about a $130 billion drop in total borrowing on quarter-ends by European dealers. Total decline in European dealer repo borrowing around quarter-ends has been around 30% in the post-Basel III period.

Third, after Basel III European dealers have been reducing their repo activity by 3.3 percentage points on month-ends that are not quarter-ends. Although, European dealers have been window-dressing their balance sheets on quarter-ends before the Basel III, they were not adjusting their repo activity on month-ends, as implied by the insignificance of the coefficient on month-end indicator. They also started contracting their balance sheets on month-ends after the implementation of Basel III since the reported ratios were based on the averages of the last three month-end values, with the exception of U.K. dealers which continued reporting based on quarter-end snapshots of their balance sheets.

Finally, we find some evidence that after the Basel III implementation, U.S. dealers started stepping into the market while European dealers were withdrawing for financial reporting purposes. The average increase in their repo borrowing on month-ends is estimated to be 4.2 percent. We do not observe any significant effect on borrowing for European dealers after Basel III was announced, and we observe only a small effect significant at 10% confidence level for U.S. dealers.

Our data set also includes information on the maturity of trades starting from January 2011. To provide further insight into how dealers manage their balance sheets on quarter-ends we also estimate Equation 1 for overnight and term repo volumes of two dealer groups separately. Tables 4 and 5 summarize the results for overnight and term repo borrowing, respectively. European dealers, on average, have been reducing their repo borrowing by 11 percent on quarter-ends through overnight transactions (Table 4), and by 8.4 percent

through term transactions (Table 5). In response to Basel III implementation of leverage ratio regulations European dealers further reduced their overnight repo borrowing by 20 percent on financial reporting days, for a total of 28.4 percent in one day. We also find evidence that European dealers' response to Basel III has mainly been through adjustments to overnight rather than term repo activity. The reduction in overnight month-end repo activity after Basel III implementation is about 9 percent. For U.S. dealers, there does not seem to be a consistent pattern neither in overnight nor in term repo borrowing. The net effect after the implementation of Basel III is near zero, consistent with the results reported in Table 3.

5 The RRP Facility and Cash Supply in the Repo Market

5.1 Identification Using the RRP Facility

When the Fed started test operations at the overnight RRP facility, it released a list of counterparties including MMFs that were eligible to participate in these operations. Eligible MMFs compare the offering rate at the facility with other market rates and determine whether to bid in the RRP operation offered each day. In addition, when dealers, the major repo borrowers, contract their balance sheets on financial reporting days, eligible MMFs have the option to go to the RRP facility, while ineligible MMFs try to invest their cash in the private market.

We now examine how the inception of the RRP facility affected repo supply in the triparty market provided by eligible and ineligible MMFs. Measuring the effects of RRP on

repo supply is a challenging task, mainly because in our first data set of daily transaction summaries, it is not possible to accurately identify MMFs at the fund level among all mutual funds, let alone determine their eligibility to participate in RRP operations. Therefore, for this exercise, we turn to our second transaction data set, which is available weekly from January 2, 2013, prior to the inception of the RRP facility. Although we cannot capture potentially different dynamics on specific calendar days using weekly data, we can quantify the overall effect of RRP operations on repo supply available to dealers.

To measure potential differences in MMF lending resulting from the RRP facility on calendar days, we also estimate daily regressions from August 22, 2014 onwards. The RRP facility was well in place—about a year after its inception—with average daily takeup around $100 billion and the number of participants around 50 for the daily sample period. Focusing on this period when daily data are available allows us to accurately measure the effects of RRP on eligible MMF lending on specific calendar days.

5.2 Empirical Analysis

Figure 7 shows the time series of lending by eligible and ineligible MMFs from January 2, 2013 to August 1, 2016. Both series are trending downward during the first half of the sample, in part, reflecting factors such as the low rate environment and the implementation of more conservative risk measures. In addition, the third round of LSAPs by the Fed reduced the supply of Treasury collateral in the market and led to a decline in repo activity for both MMF groups.

To quantify the response of MMF lending to the inception of the RRP facility, we take the log weekly series which have 180 observations, and first check for a potential unit root in each series, using tests that are powerful againts persistent alternatives, such as Elliott

et al. (1996) and Ng and Perron (2001). Although standard unit root tests fail to reject the null of unit root, visual investigation of the data suggests the existence of structural breaks.[13] Using the Quandt-Andrews unknown breakpoint test, we find evidence of a break in 2014:W28 for eligible MMF lending, and in 2014:W17 for ineligible lending. Once we allow for a structural break in the cointegrating equation using a modified augmented Dickey-Fuller test, we confirm that the series do not exhibit unit root behavior, but they instead include a break. Both breaks are during the period after the RRP operations started.[14] To prevent the breaks from distorting the results, we regress the two series on indicator variables corresponding to their break dates and retrieve the residual series, which are stationary.

After we account for breaks, we estimate the following regression, separately for eligible and ineligible MMF lending to quantify the effect of the RRP facility.

$$RL_t = \beta_0 + \beta_1 RL_{t-1} + \psi_1 RRP_t^{Sep.23} + \psi_2 RRP_t^{Dec.23} + \epsilon_t \tag{2}$$

We consider two RRP indicators: $RRP_t^{Sep.23}$ takes the value 1 from September 23, 2013, to December 23, 2013 and 0 otherwise, and represents the first three months of the overnight RRP facility that is associated with frequent changes to facility parameters. During this initial stage of testing, takeup at the facility was very low amid small individual 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, $RRP_t^{Dec.23}$, marks the beginning of this period during which the facility became

[13] Perron (1989) points out that conventional unit root tests are biased towards a false unit root null when the data is stationary and include a structural break. See Hansen (2001) for a comprehensive review of the literature on structural breaks.

[14] For brevity, we do not report the unit root and structural break test statistics. They are available upon request.

an important factor affecting repo market dynamics. We also account for autocorrelation by including the first lag of lending by MMFs.

Table 6 shows the results for the two groups of MMFs. As expected, there is no significant response of MMF lending in the triparty repo market to the official start date of the operations on September 23, although we find evidence of a shift in eligible MMF in response to the second indicator variable, $RRP_t^{Dec.23}$. Once the RRP facility became a significant factor for investment decisions of eligible money funds, their lending declined by 16% in the triparty market. While we find a statistically and economically significant effect of RRP facility on eligible MMF lending, we do not find any RRP effects on ineligible MMF lending.

Having showed that the RRP facility was a shock to the overall cash supply in the repo market, we now zoom into calendar days using daily data to identify potentially different dynamics for eligible and ineligible MMFs. The behaviors of eligible and ineligible MMFs are expected to differ mainly on specific calendar days when investing in the private market becomes difficult. To quantify potential changes in repo lending by MMFs on certain calendar days, we focus on the sample available from August 22, 2014 to August 1, 2016. We run a regression of the log of daily repo lending by the two groups of MMFs on indicator variables that represent quarter-ends, and month-ends that are not quarter-ends.

$$RL_t = \beta_0 + \beta_1 RL_{t-1} + \psi_1 (Quarter - end)_t + \psi_2 (Month - end)_t + \epsilon_t \tag{3}$$

where ψ_1 measures the change in MMF repo lending on quarter-ends, and ψ_2 on month-ends that are not quarter-ends.

Table 7 reports the results for daily lending by eligible and ineligible MMFs to dealers in columns (1) and (2), respectively. We see that, on quarter-ends, eligible MMF lending to dealers declines by almost half, as indicated by the coefficient estimate significant at the 1%

confidence level. In contrast, there is no significant reaction by ineligible MMFs on these days, as indicated by the near-zero coefficient in column (2). The reason is that eligible funds have the overnight RRP as an investment option—which provides convenience especially on calendar days when dealers withdraw from the repo market—while ineligible funds do not have this option.

Another observation from Table 7 is that the time series process for ineligible lending is much more persistent than that for eligible lending, with AR(1) coefficients of 0.94 and 0.44, respectively. This outcome indicates that ineligible funds, unlike eligible funds, do not have the flexibility to allocate their funds between overnight RRP and private repo in the triparty market. In other words, even on days when their primary borrowers withdraw from the market, ineligible funds need to find other options to invest their cash likely by offering competitive rates to other repo borrowers.

Finally, we do not find any significant response on month-ends by either of these two groups, which we anticipated for this sample starting on August 22, 2014. When Basel III regulations were announced in June 2013, European banks were required to calculate their leverage ratios as the simple average of three month-end values over a quarter. We indeed find evidence of window-dressing on month-ends for the overall sample, as dicussed in Section 4. However, in October 2014, this rule was amended to require reporting at the end of the quarter rather than on a three-month average basis. This change in the rule eliminated the incentive for European dealers to shrink their balance sheets on month-ends, as reflected in our results for the sample starting from August 22, 2014.

6 Trading Relationships in the Triparty Repo Market

6.1 Measuring Trading Relationship Strength

We construct two measures of trading relationship strength (TRS) between MMF i and dealer j that are calculated weekly. TRS measures capture the concentration of lending by MMF i to a specific dealer j from two perspectives: the transaction volume (TRV) and the transaction frequency (TRF). The two measures are based on the transactions of each lender borrower pair over week t and defined from the perspective of the lender. These statistics can be written as follows:

$$TRV_{ij,t} = \frac{\text{Lending by MMF } i \text{ to dealer } j \text{ over week } t}{\text{Total lending by MMF } i \text{ over week } t} \tag{4}$$

$$TRF_{ij,t} = \frac{\text{Number of transactions between MMF } i \text{ and dealer } j \text{ over week } t}{\text{Total number of transactions by MMF } i \text{ over week } t} \tag{5}$$

$TRV_{ij,t}$ focuses on the amount transacted by the specific trading pair, while $TRF_{ij,t}$ measures the frequency of trading between the two parties at week t. Both the TRV and TRF measures take a value between 0 and 1, with higher values indicating stronger relationships.

6.2 Identification Strategy

Having provided evidence of intensified window-dressing by European dealers in response to Basel III regulations, and the effects of the Fed's RRP facility on MMFs' cash supply in the repo market, we now turn to MMF dealer relationships. Specifically, we examine whether the intensification of window-dressing by European dealers hurt relationships with their MMF

counterparties. We also analyze if intermediation by the Fed through the overnight RRP facility affected the relationship strength between the two trading parties.

The DID setting allows us to measure the effects of implementation differences as well as the overnight RRP facility on trading relationships while controlling for other factors that might affect trading dynamics in the repo market. We exploit the regional differences in implementation of the Basel III leverage ratio requirements to define our treatment and control groups. The Basel III implementation constitutes a demand shock to the repo market, as it affected the behavior of European dealers (treatment group) as opposed to U.S. dealers (control group), as shown in Section 4. Moreover, in Section 5, we showed that the inception of the Fed's RRP facility affected the supply side of the market by providing an alternative investment vehicle to eligible Fed counterparties. These plausibly exogenous demand and supply shocks to the repo market provide a convenient DID setup to study potential changes to relationship structure that are unrelated to the risk profile of the MMFs and dealers.

For eligible MMFs, the effect of window-dressing on trading relationships may be different than it is for ineligible MMFs, because eligible MMFs have an alternative investment option at the RRP facility when European dealers withdraw from the market on financial reporting days. Therefore, we study the effect of Basel III leverage ratio requirements on trading relationships separately for eligible and ineligible MMF groups.

6.3 Empirical Analysis

We estimate, for eligible and ineligible MMFs, the following weekly DID regression at the relationship level for the two TRS measures:

$$TRS_{ij,t} = \beta_0 + \beta_1 TRS_{ij,t-1} + \theta_1\big(EUD_j \times Implemented_t\big) + \phi_t + \delta_{ij} + \theta_2\big(X_i \times Implemented_t\big) + \epsilon_{ij,t} \tag{6}$$

where $TRS_{ij,t} = \{TRV_{ij,t}, TRF_{ij,t}\}$ is the outcome of interest for MMF i and dealer j in week t. EUD is an indicator variable that equals 1 if dealer i is a European dealer. *Implemented* is an indicator variable that equals 1 after Basel III was implemented, i.e. after June 15, 2014.[15]The main coefficient of interest is θ_1, which reflects the change in TRS for European dealers in comparison with U.S. dealers after the implementation of the Basel III leverage ratio requirements.

We consider the possibility that relationships between (in)eligible MMFs and European and U.S. dealers may differ in ways that are correlated with the TRS, and hence bias the estimates. We address this potential problem by controlling for the initial characteristics of MMFs as well as their interaction with the *Implemented* indicator variable. That way, we ensure that the results are driven not by the typical repo trading dynamics of European versus U.S. dealers but instead by the regional implementation differences of Basel III (Barrot (2016)). The measures of MMF initial characteristics we consider are the monthly averages of their AUM, flows, and their average overnight repo outstanding from January 1, 2013, to July 1, 2013.

We include relationship fixed effects, δ_{ij}, to avoid potential bias that could result from time-invariant relationship characteristics. For example, δ_{ij} allows us to control for unobservable differences between eligible and ineligible MMFs. Additionally, we include week

[15]We do not separately include *Implemented* or EUD indicators since they are absorbed by time and relationship fixed effects.

fixed effects, ϕ_t, to account for time trends in the outcome variable, alleviating the concern that the implementation of Basel III may have occurred around the same time with other changes in relationship strength. Finally, we also include the first lag of TRS to account for autocorrelation in the dependent variable. Standard errors are clustered at the relationship level to account for cross-sectional correlation, following Petersen (2009) and Bertrand et al. (2004).

The assumption of parallel trends between the control and treatment groups in the absence of different regulatory requirements is crucial for the validity of the DID estimation. Figures 8 and 9 plot weekly average values of the two relationship strength measures, TRV and TRF, calculated separately for U.S. and domestic dealers. Before the implementation of Basel III leverage ratio requirements, trends in TRV and TRF are parallel for the two types of dealers, consistent with the main DID assumption for the pre-treatment period. After the Basel III implementation date, both measures for European dealers decline substantially, moving away from the common trend with the U.S. dealers up to that point. Overall, these figures provide evidence of the parallel trends assumption for the two groups of dealers.

Tables 8 and 9 report the results from the DID estimation of the effect of Basel III leverage ratio implementation on TRV for eligible and ineligible MMF dealer relationships, respectively. We find that eligible MMFs lend 3.1 percentage points more to European dealers in comparison with U.S. dealers after the Basel III implementation took place (7.5% increase in total MMF lending). Column (2) of Table 8 shows the results when MMF control variables are added to interact with the indicator variable, $Implemented$. The coefficient on $(EUD \times Implemented)$ is little changed at 3.3 percentage points. These results suggest that Basel III implementation led to stronger relationships between eligible MMFs and European dealers.

We also consider two additional interaction terms of EUD and indicator variables representing the introduction of the overnight RRP facility. The first indicator is equal to 0 prior to the inception of the facility on September 23, 2013, and then equal to 1 until December 23, 2013, when the takeup increased significantly following the increase in individual bid size to $5 billion. The second indicator variable is equal to 1 from December 23, 2013 onwards, and zero prior to that. The coefficients associated with these interaction terms are always insignificant and near zero, implying no differential behavior between the treated and the control groups prior to the Basel III implementation. This result provides further evidence for the parallel trends assumption, which is crucial for the DID estimation.

As for ineligible MMF dealer relationships, as shown in Table 9, ineligible MMFs lend 2.8 percentage points less to European dealers, in comparison with U.S. dealers, which accounts for about 7% of total MMF lending. In column (2), we find that the coefficient on $EUD \times Implemented$ remains almost the same after adding MMF control variables, implying that potential differences in MMF characteristics are not driving the results. Overall, these results imply that lending by ineligible MMFs to European dealers decreased by nearly 15%, compared with eligible MMFs.

When we focus on TRF that is based on the frequency of transactions between the counterparties rather than the transaction volume, we do not find a significant change for eligible MMFs and European dealers (Table 10). However, we find that ineligible MMFs reduced their lending to dealers by 1.4 percentage points (column (1) of Table 11), which is robust to an inclusion of various control variables (column (2) of Table 11).

Our results suggest that ineligible MMFs found it inconvenient to continue trading with European dealers after window-dressing was intensified in the post Basel III period. Meanwhile, eligible MMFs considered the RRP facility as a convenient alternative when European

dealers withdrew from the market on financial reporting days. Although we do not find any significant increase in the number of transactions, eligible MMFs increased the amount of their lending to European dealers, perhaps because the RRP facility served as a backstop on certain calendar days. Therefore, eligible MMFs were likely to strengthen their relationships with European dealers, while ineligible MMFs were reducing their exposure to those dealers following Basel III, mainly because of dealers' window-dressing.

In our estimations, we do not condition on existing relationships of MMFs and dealers prior to the implementation of the Basel III framework. Therefore, estimates also incorporate the effects of potential new relationship formation over time. Alternatively, one can also consider the possibility that a relationship between an eligible MMF and a dealer might be different from a relationship between an ineligible MMF and a dealer for other reasons that are uncorrelated with the outcome variable. Being agnostic as to why the relationship was created in the first place, we also perform a robustness check where we impose the condition that each MMF has a prior relationship with the dealers it trades with after the Basel III implementation. We obtain slightly different estimates under this assumption, but our main findings remain robust.

7 Concluding Remarks

We analyze trading dynamics in the repo market in the wake of Basel III regulations and the Fed's monetary policy implementation framework. First, we document that European dealers were reducing their repo borrowing in the triparty market by 10% on quarter-ends to look more attractive to their regulators on financial reporting days, before the Basel III regulations took effect. We find that the implementation of Basel III intensified window-

dressing by European dealers, leading to a total of 17% decline in their repo borrowing on the reporting day. Total decline in European dealer repo borrowing around quarter-ends has been around 30% in the post-Basel III period.

We then show that the RRP facility led to a 16% decline in eligible MMF lending in the triparty market. The behaviors of eligible and ineligible funds particularly differ on financial reporting days when investing in the private market becomes difficult. Since eligible MMFs have the RRP as an alternative investment vehicle, they cut their lending to dealers by about 46%, when some dealers withdraw from the market for reporting purposes. We do not find any change in the behavior of ineligible MMFs, reflecting their inflexibility, relative to eligible MMFs.

Once we identify the effects of Basel III and the Fed's RRP facility on demand and supply in the repo market, respectively, we examine dealer-MMF relationships in a DID setting. We find that those MMFs that cannot trade with the Fed lent 15% less to European dealers that withdrew from the repo market on financial reporting days, compared with ineligible MMFs. This result suggests that without the Fed's RRP facility, window-dressing would likely have increased funding costs for European 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. Washington: Board of Governors of the Federal Reserve System.

Adrian, T. and H. S. Shin (2010): "Liquidity and Leverage," *Journal of Financial Intermediation*, 19, 418–437.

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

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

Agarwal, V., G. D. Gay, and L. Ling (2014): "Window Dressing in Mutual Funds," *The Review of Financial Studies*, 27, 3134–3170.

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

Anderson, A. and J. Kandrac (2016): "Monetary Policy Implementation and Private Repo Displacement: Evidence from the Overnight Reverse Repurchase Facility," Unpublished Manuscript.

Barrot, J.-N. (2016): "Trade Credit and Industry Dynamics: Evidence from Trucking Firms," *The Journal of Finance*, 71.

Bertrand, M., E. Duflo, and S. Mullainathan (2004): "How Much Should We Trust Differences-in-Differences Estimates?" *The Quarterly Journal of Economics*, 119, 249–275.

Bharath, S. T., S. Dahiya, A. Saunders, and A. Srinivasan (2011): "Lending Relationships and Loan Contract Terms," *The Review of Financial Studies*, 24, 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, 1717–1750.

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

Copeland, A., A. Martin, and M. Walker (2014): "Repo Runs: Evidence from the Tri-Party Repo Market," *Journal of Finance*, 69, 2343–2380.

Dass, N. and M. Massa (2011): "The Impact of a Strong Bank-Firm Relationship on the Borrowing Firm," *The Review of Financial Studies*, 24, 1204–1260.

DiMaggio, M., A. Kermani, and Z. Song (forthcoming): "The Value of Trading Relationships in Turbulent Times," *Journal of Financial Economics*.

Elliott, G., T. J. Rothenberg, and J. H. Stock (1996): "Efficient Tests for an Autoregressive Unit Root," *Econometrica*, 64, 813–836.

Gorton, G. and A. Metrick (2012): "Securitized Banking and the Run on Repo," *Journal of Financial Economics*, 104, 425–451.

Han, S. and K. Nikolaou (2016): "Trading Relationships in the OTC Market for Secured Claims:Evidence from Triparty Repos," *Finance and Economics Discussion Series 2016-064. Washington: Board of Governors of the Federal Reserve System.*

Hansen, B. E. (2001): "The New Econometrics of Structural Change," *Journal of Economic Perspectives*, 15, 117–128.

Hendershott, T., D. Li, D. Livdan, and N. Schrhoff (2016): "Relationship Trading in OTC Markets," *AFA 2016 Meeting Paper*.

Ihrig, J. E., G. C. Weinbach, and E. E. Meade (2015): "Rewriting Monetary Policy 101: Whats the Feds Preferred Post-Crisis Approach to Raising Interest Rates?" *Journal of Economic Perspectives*, 29, 177–198.

Klee, E., Z. Senyuz, and E. Yoldas (2016): "Effects of Changing Monetary and Regulatory Policy on Overnight Money Markets," *Finance and Economics Discussion Series 2016-084. Washington: Board of Governors of the Federal Reserve System.*

Kreicher, L. L., R. N. McCauley, and P. McGuire (2013): "The 2011 FDIC Assessment on Banks Managed Liabilities: Interest Rate and Balance Sheet Responses," *BIS Working Papers No. 413*.

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

Lakonishok, J., A. Shleifer, R. Thaler, and R. Vishny (1991): "Window Dressing by Pension Fund Managers," *The American Economic Review*, 81, 227–231.

Munyan, B. (2015): "Regulatory Arbitrage in Repo Markets," *Office of Financial Research Working Paper*.

Ng, S. and P. Perron (2001): "Lag Length Selection and the Construction of Unit Root Tests with Good Size and Power," *Econometrica*, 69, 1519–1554.

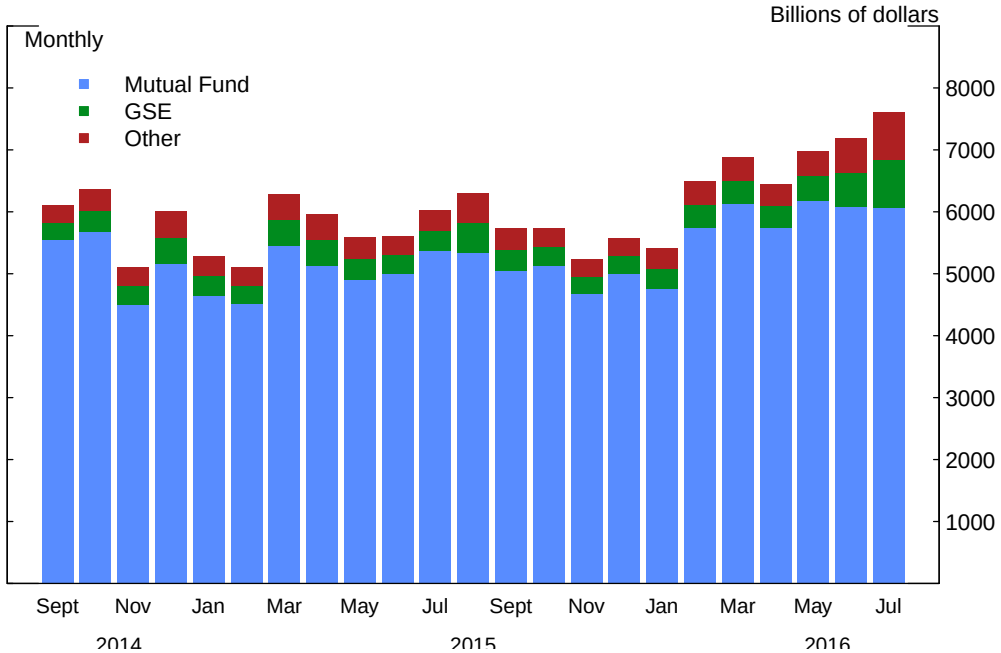
Perron, P. (1989): "The Great Crash, the Oil Price Shock, and the Unit Root Hypothesis," *Econometrica*, 57, 1361–1401.

Petersen, M. A. (2009): "Estimating Standard Errors in Finance Panel Data Sets: Comparing Approaches," *The Review of Financial Studies*, 22, 435–480.

Sias, R. W. and L. T. Starks (1997): "Institutions and Individuals at the Turn-of-the-Year," *The Journal of Finance*, 52, 1543–1562.

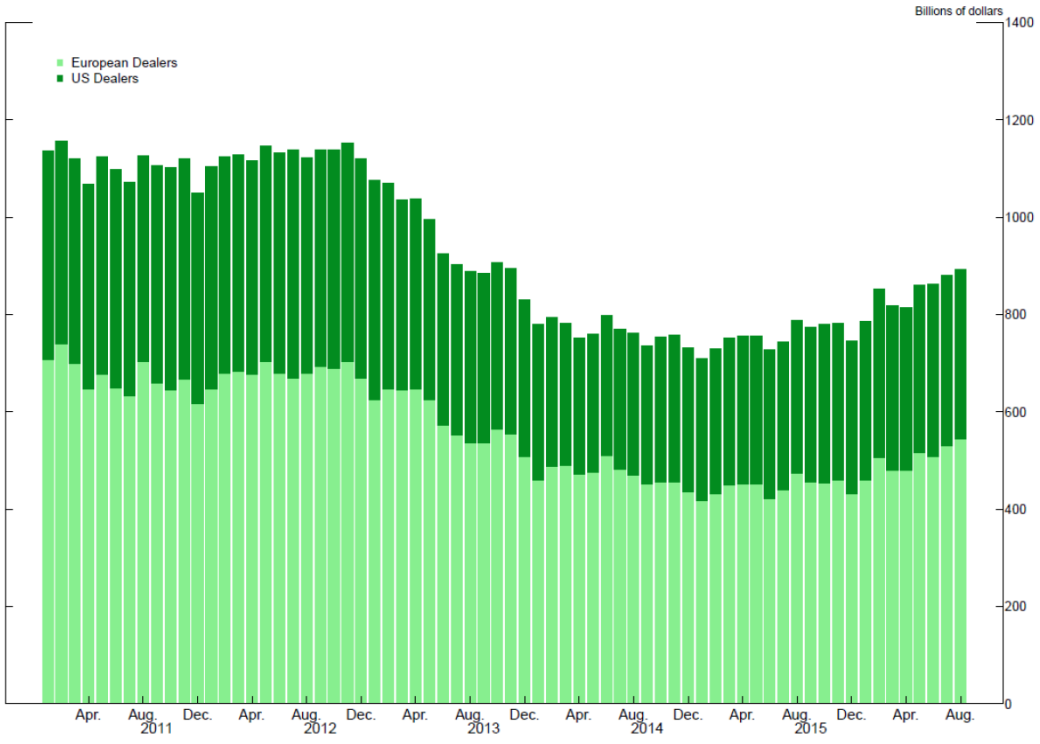
Figures and Tables

Figure 1: Tri-Party Repo Lending by type



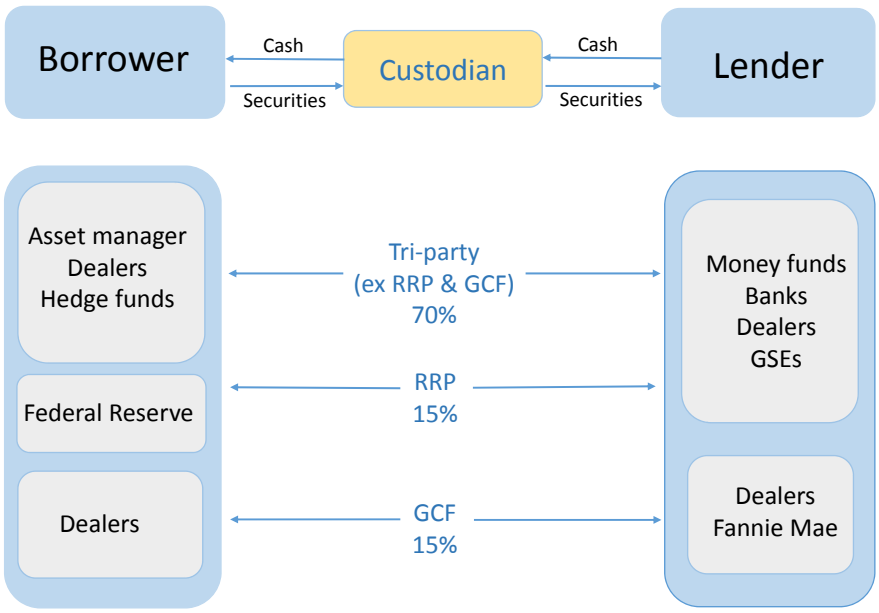
Note: Data on daily summaries of triparty repo transactions are obtained from the FRBNY, and aggregated monthly. The sample shown here is from August 2014 to August 2016.

Figure 2: TriParty Repo Borrowing by Dealers



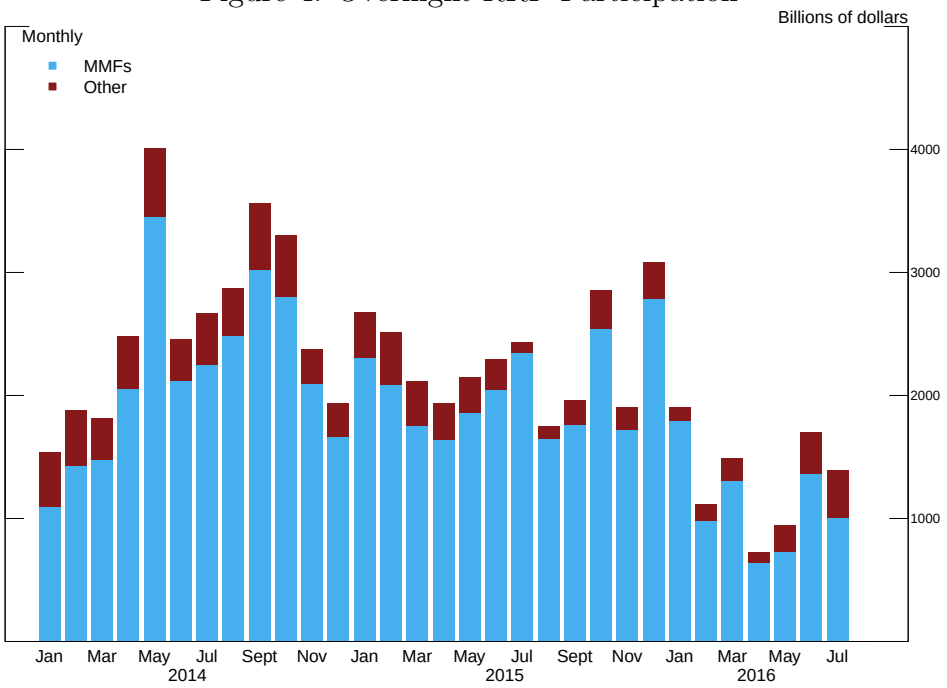
Note: Data on daily summaries of triparty repo transactions are obtained from the FRBNY, and aggregated monthly. The sample shown here is from January 2011 to August 2016.

Figure 3: TriParty Repo Market Mapping



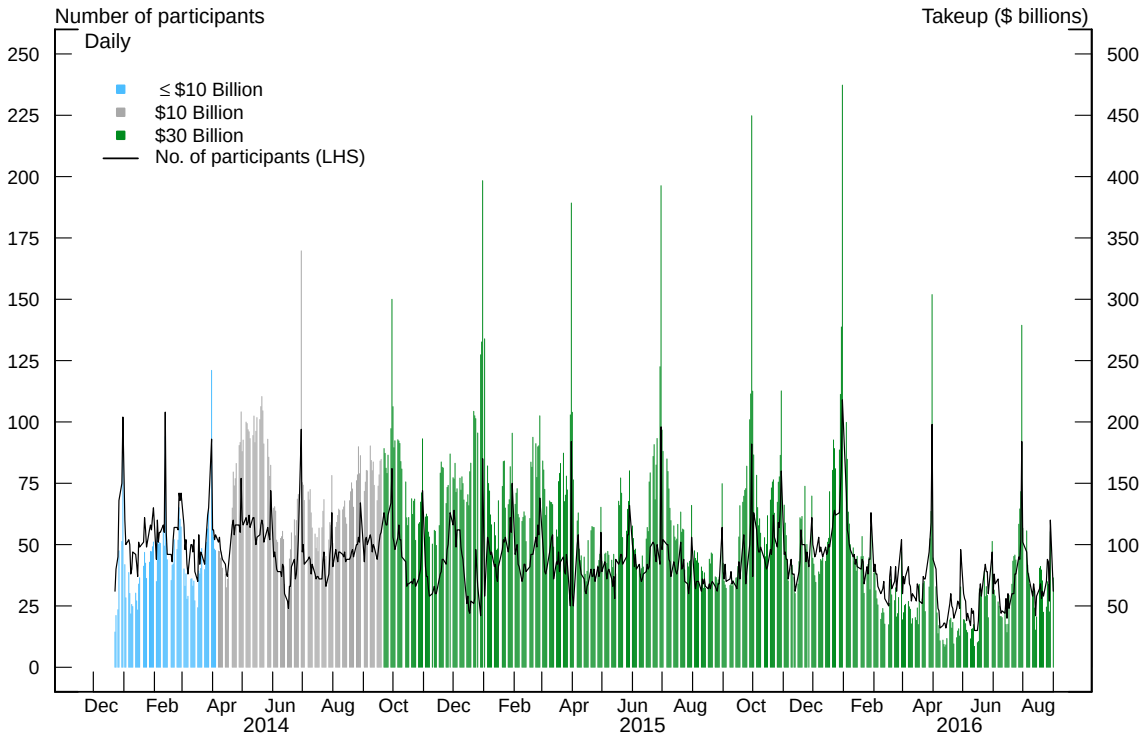
Note: The triparty GC repo platform consists of repo transactions for which Bank of New York Mellon and JP Morgan are the custodian banks, interdealer transactions that take place in the GCF segment, and transactions with the Fed via the RRP. Average shares of each segment shown above fluctuates on certain calendar days, such as quarter-ends.

Figure 4: Overnight RRP Participation



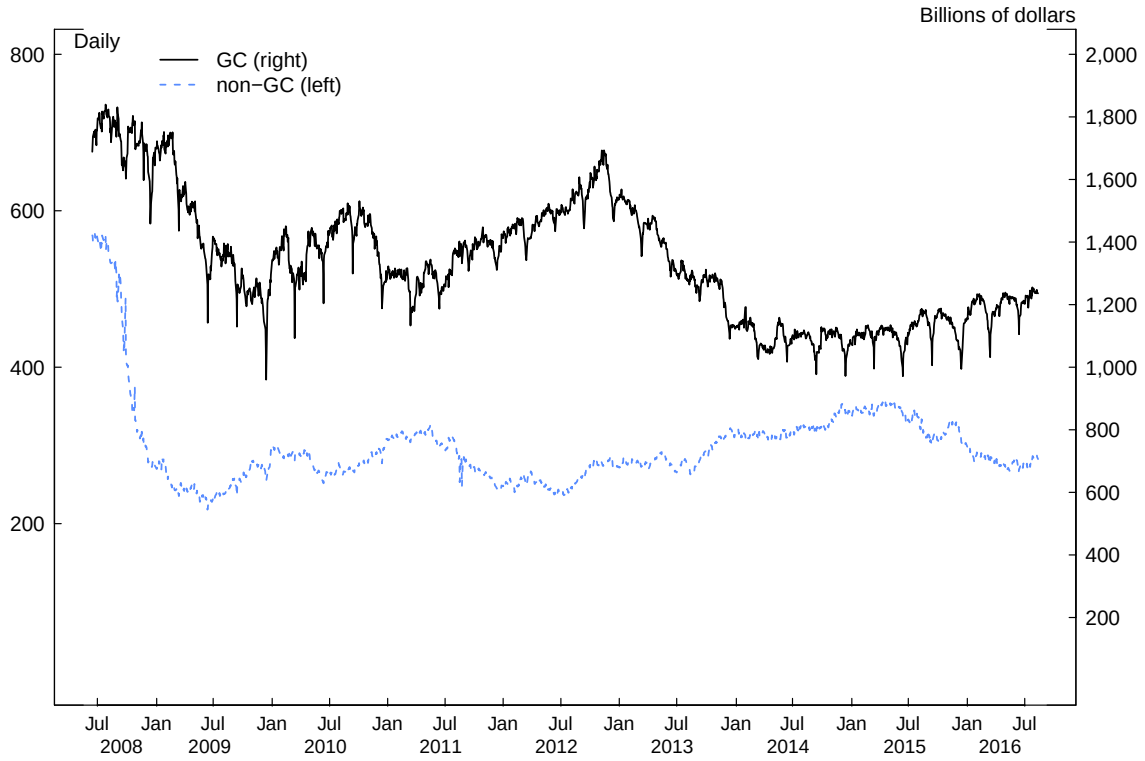
Note: Data on overnight RRP take-up by counterparty type are available from the FRBNY. The monthly sample shown here is from January 2014 to August 2016.

Figure 5: RRP Facility Usage



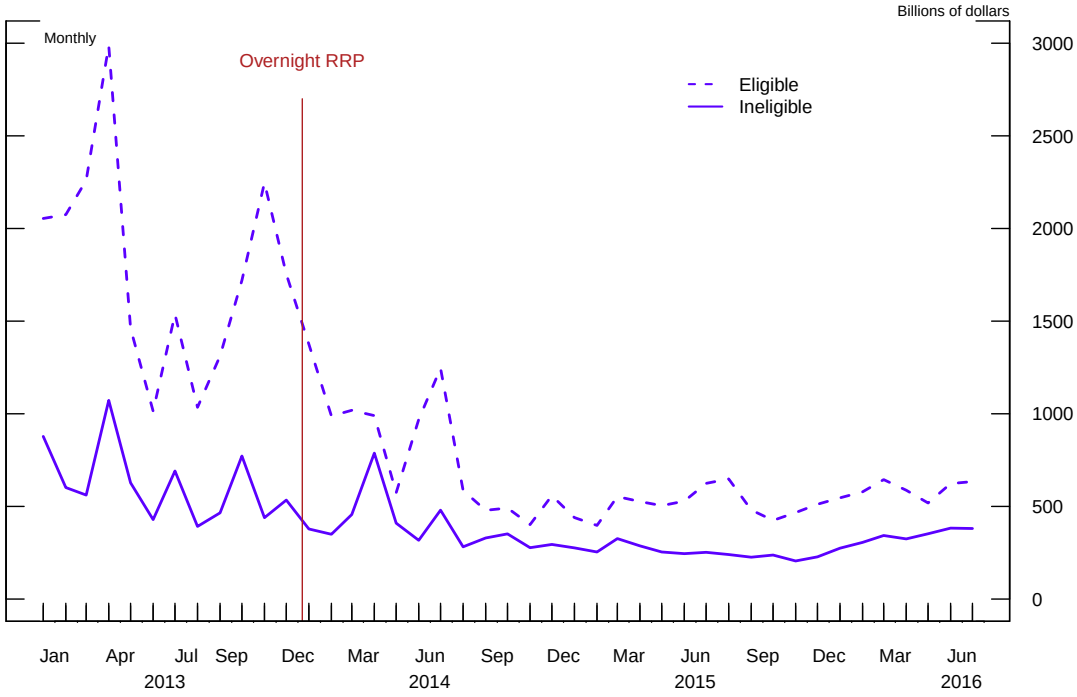
Note: RRP takeup shown here includes both overnight and term RRP operations. Data on overnight and terrm RRP takeup are available from the FRBNY. The daily sample shown here is from December 23, 2013, to August 1, 2016.

Figure 6: Daily Triparty Repo Outstanding



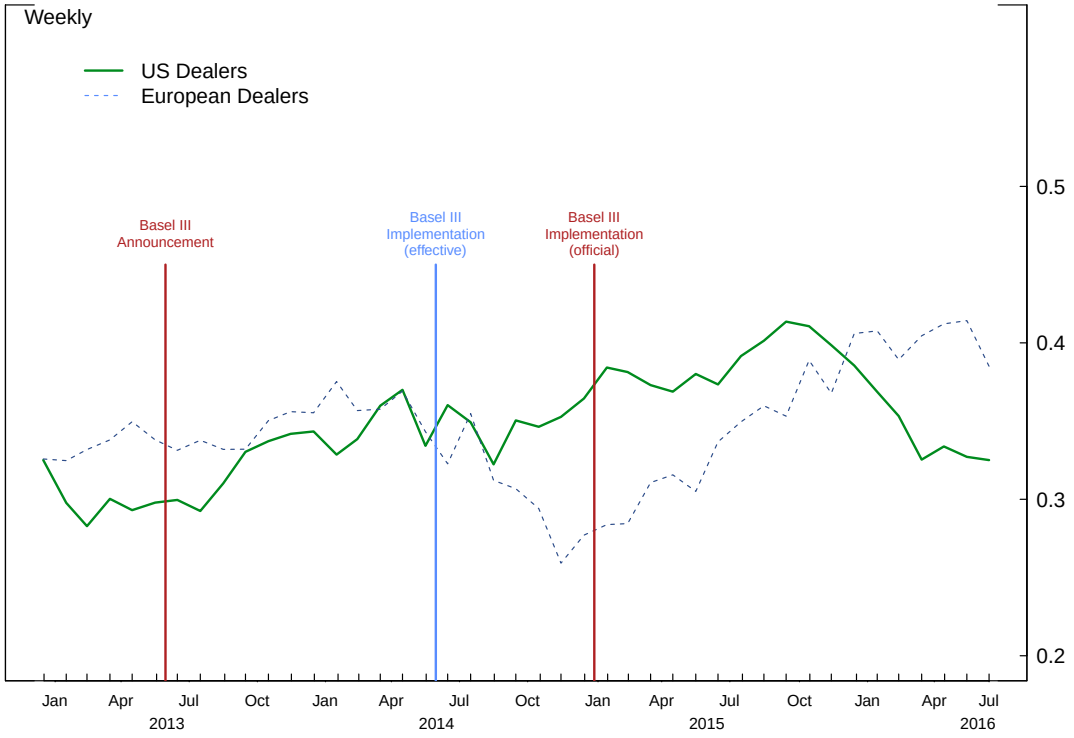
Note: Data on daily summaries of triparty repo transactions are obtained from the FRBNY. The daily sample is from from July 1, 2008 to August 1, 2016

Figure 7: MMF Lending



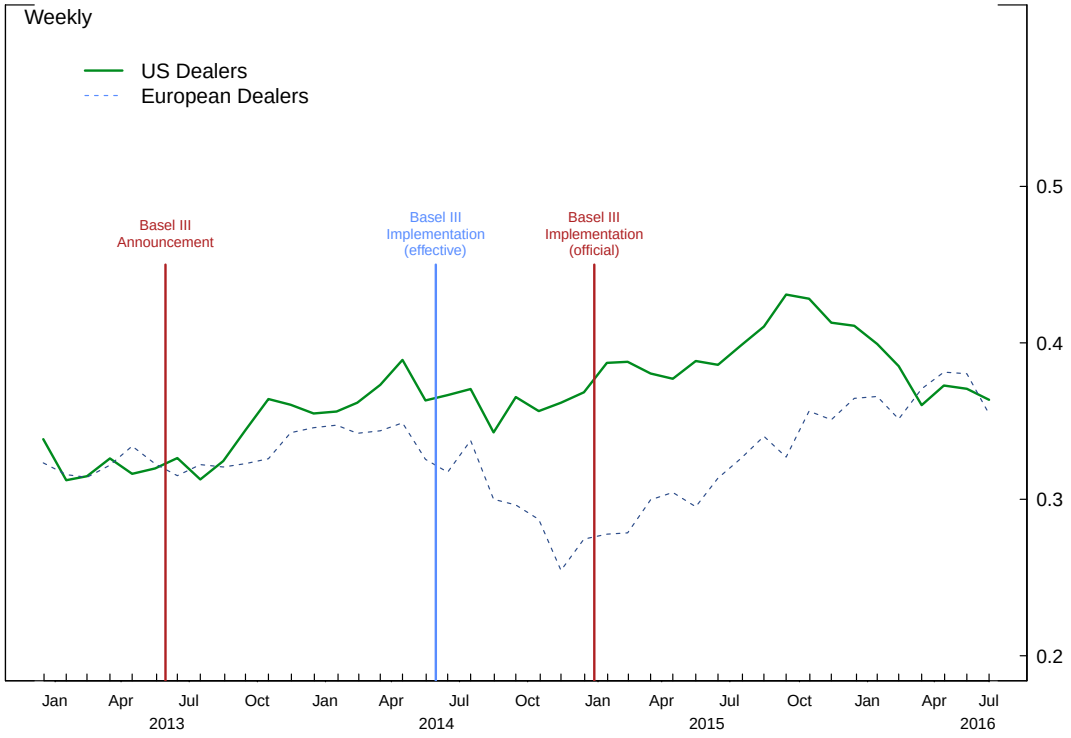
Note: Data on daily summaries of triparty repo transactions are obtained from the FRBNY. The weekly sample is from January 1, 2013, to August 1, 2016

Figure 8: Trends in Trading Relationship Strength: TRV



Note: TRV is based on the weekly average amount of transactions of MMFs with U.S. and European dealers, from January 2, 2013 to August 1, 2016.

Figure 9: Trends in Trading Relationship Strength: TRF



Note: TRF is calculated as the weekly average number of transactions of MMFs with U.S. and European dealers, from January 2, 2013 to August 1, 2016.

Table 1: Summary Statistics for Tri-Party Repo Outstanding

Asset Class	Overnight		Term	
	Avg. Volume	Std. Dev.	Avg. Volume	Std. Dev.
Agency CMOs	45	18	46	12
Agency Debentures	66	28	21	12
Agency MBS	282	79	241	65
U.S. Treasuries	480	81	140	71
Total GC Collateral	874	140	449	129
Total non-GC Collateral	86	29	209	46
All Collateral	960	160	658	144

Note: Data on the daily summaries of triparty repo transactions are obtained from the FRBNY. The figures are in billion dollars and show the size and composition of assets pledged as collateral in the triparty repo market from January 2, 2011 to August 1, 2016, with the maturity breakdown of trades into overnight and term.

Table 2: Summary Statistics for Tri-Party Transaction-level Data

Items	No. of Transactions
Eligible MMFs	19.183 (42%)
Ineligible MMFs	27.037 (58%)
European Dealers	25.282 (55%)
U.S. Dealers	20.938 (45%)
Transactions	46.220

Note: Tri-party repo transaction-level data are obtained from the FRBNY. The data are reported by Bank of New York Mellon to FRBNY, and available from January 2, 2013, to August 1, 2016.

Table 3: Total Repo Borrowing by Dealers on Calendar Days and Effects of Regulations

	(1) European Total Repo Borrowing	(2) U.S. Total Repo Borrowing
Quarter-end x Announced	0.025	0.028*
	(1.21)	(1.86)
Quarter-end x Implemented	-0.076***	0.042***
	(-3.74)	(3.13)
Month-end (not Quarter-end) x Implemented	-0.033***	-0.006
	(-4.36)	(-1.01)
Quarter-end (-5)	-0.011**	-0.004
	(-2.52)	(-1.27)
Quarter-end (-4)	-0.018***	0.001
	(-3.47)	(0.31)
Quarter-end (-3)	-0.016***	-0.001
	(-2.98)	(-0.19)
Quarter-end (-2)	-0.031***	0.000
	(-5.45)	(0.14)
Quarter-end (-1)	-0.045***	-0.009**
	(-4.72)	(-2.48)
Quarter-end	-0.098***	0.003
	(-6.35)	(0.30)
Quarter-end (+1)	0.099***	-0.005
	(4.70)	(-0.42)
Quarter-end (+2)	0.015**	-0.001
	(2.04)	(-0.35)
Quarter-end (+3)	0.004	-0.003
	(0.66)	(-0.91)
Quarter-end (+4)	0.006	-0.001
	(0.88)	(-0.17)
Quarter-end (+5)	0.001	0.007*
	(0.13)	(1.78)
Month-end (not Quarter-end)	-0.006	0.011***
	(-1.44)	(2.99)
Total Borrowing (-1)	0.916***	0.948***
	(16.97)	(32.77)
Observations	1585	1585
R^2	0.965	0.957

Note: This table presents the results of time series regressions for the log of total repo borrowing by European and U.S. dealers, in columns 2 and 3, respectively. Daily sample runs from July 1, 2008, to August 1, 2016. t-ratios are reported in parentheses and are calculated using robust standard errors.

Table 4: Overnight Repo Borrowing by Dealers on Calendar Days and Effects of Regulations

	(1) European Overnight Borrowing	(2) U.S. Overnight Borrowing
Quarter-end x Announced	-0.021	0.030
	(-0.59)	(1.14)
Quarter-end x Implemented	-0.195***	0.066
	(-5.93)	(1.62)
Month-end (not Quarter-end) x Implemented	-0.085***	0.003
	(-4.68)	(0.17)
Quarter-end (-5)	-0.006	0.016
	(-0.97)	(1.53)
Quarter-end (-4)	-0.035***	-0.014
	(-2.59)	(-1.01)
Quarter-end (-3)	-0.014	-0.003
	(-1.07)	(-0.32)
Quarter-end (-2)	-0.052***	-0.008
	(-5.82)	(-1.30)
Quarter-end (-1)	-0.045***	0.032***
	(-4.19)	(4.09)
Quarter-end	-0.107***	0.037
	(-4.48)	(1.47)
Quarter-end (+1)	0.152***	-0.047***
	(5.42)	(-3.31)
Quarter-end (+2)	0.020***	0.004
	(2.70)	(0.35)
Quarter-end (+3)	-0.010	-0.010
	(-0.98)	(-1.21)
Quarter-end (+4)	-0.002	-0.010
	(-0.23)	(-0.83)
Quarter-end (+5)	0.017*	0.015
	(1.74)	(1.64)
Month-end (not Quarter-end)	-0.010	0.006
	(-1.39)	(0.58)
Overnight Borrowing (-1)	0.885***	0.957***
	(55.55)	(98.95)
Observations	1056	1056
R^2	0.978	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 2 and 3, respectively. Daily sample runs from January 2, 2011, to August 1, 2016.t-ratios are reported in parentheses and are calculated using robust standard errors.

Table 5: Term Repo Borrowing by Dealers on Calendar Days and Effects of Regulations

	(1) European Term Borrowing	(2) U.S. Term Borrowing
Quarter-end x Announced	0.059**	-0.111***
	(2.52)	(-4.14)
Quarter-end x Implemented	0.041	-0.085***
	(1.50)	(-3.80)
Month-end (not Quarter-end) x Implemented	-0.010	-0.043**
	(-0.61)	(-2.44)
Quarter-end (-5)	-0.020	-0.012
	(-1.49)	(-1.23)
Quarter-end (-4)	-0.000	0.016**
	(-0.03)	(2.28)
Quarter-end (-3)	-0.025**	-0.003
	(-2.37)	(-0.32)
Quarter-end (-2)	-0.014*	0.022***
	(-1.67)	(3.16)
Quarter-end (-1)	-0.042***	-0.060***
	(-4.67)	(-3.66)
Quarter-end	-0.084***	0.075***
	(-3.62)	(6.96)
Quarter-end (+1)	0.056**	0.013**
	(2.36)	(2.50)
Quarter-end (+2)	0.016	0.002
	(1.58)	(0.16)
Quarter-end (+3)	0.026***	0.011
	(3.80)	(0.79)
Quarter-end (+4)	0.014*	0.015
	(1.93)	(1.44)
Quarter-end (+5)	-0.017*	-0.007
	(-1.80)	(-0.74)
Month-end (not Quarter-end)	0.017	0.045***
	(1.52)	(3.15)
Term Borrowing (-1)	0.949***	0.956***
	(91.84)	(106.76)
Observations	1056	1056
R^2	0.927	0.930

Note: This table presents the results of time series regressions for the log of term repo borrowing by European and U.S. dealers, in columns 2 and 3, respectively. Daily sample runs from January 2, 2011, to August 1, 2016.t-ratios are reported in parentheses and are calculated using robust standard errors.

Table 6: Effects of RRP on Repo Lending to Dealers

	(1) Eligible MMF	(2) Ineligible MMF
RRP (Sep. 23)	0.03	-0.08
	(0.25)	(-0.8)
RRP (Dec. 23)	-0.16^{***}	-0.10
	(-2.32)	(-1.56)
Repo Lending	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. Weekly sample runs from January 2, 2013, to August 1, 2016, and is obtained from the FRBNY. Dealers comprise of all European and U.S. dealers in our sample. t-ratios are reported in parentheses and are calculated using robust standard errors.

Table 7: RRP and Calendar Day Effects on Repo Lending to Dealers

	(1) Eligible MMF	(2) Ineligible MMF
Quarter-end	-0.458^{***}	-0.002
	(-6.84)	(-0.05)
Month-end	-0.296	-0.248
	(-1.25)	(-1.22)
Repo Lending (-1)	0.435^{**}	0.935^{***}
	(2.31)	(14.71)
Observations	369	363
R^2	0.0968	0.2932

Note: This table presents the results of time series regressions for the log of daily repo lending by eligible and ineligible MMFs to dealers. Daily sample runs from August 22, 2014, to August 1, 2016, and is obtained from FRBNY. Dealers comprise of all European and U.S. dealers in our sample. t-ratios are reported in parentheses and are calculated using robust standard errors.

Table 8: Effects of Regulations on TRV: RRP-eligible MMFs and dealers

	(1) Eligible MMF	(2) Eligible MMF
EUD x Sep 23, 2013	-0.000	0.001
	(-0.01)	(0.13)
EUD x Dec 23, 2013	0.010	0.012
	(0.55)	(0.67)
EUD x Implemented	0.031**	0.033**
	(2.32)	(2.49)
TRA (t-1)	0.615***	0.609***
	(19.90)	(19.96)
Time FE	Yes	Yes
Relationship FE	Yes	Yes
Controls x Implemented	No	Yes
Observations	16515	16515
R^2	0.7465	0.7473

Note: This table presents the results of the DID estimates of the effect of Basel III regulations and the overnight RRP facility on trading relationship strength of RRP-eligible MMFs and dealers, as measured by the TRV. TRV is calculated based on the dollar amount of transactions between the two parties. t-ratios reported in parentheses are calculated using standard errors clustered at the relationship level.

Table 9: Effects of Regulations on TRV: RRP-ineligible MMFs

	(1) Ineligible MMF	(2) Ineligible MMF
EUD x Sep 23, 2013	-0.004	-0.004
	(-0.66)	(-0.68)
EUD x Dec 23, 2013	-0.003	-0.003
	(-0.30)	(-0.31)
EUD x Implemented	-0.028***	-0.029***
	(-2.80)	(-2.89)
TRA (t-1)	0.677***	0.675***
	(31.11)	(32.12)
Time FE	Yes	Yes
Relationship FE	Yes	Yes
Controls x Implemented	No	Yes
Observations	25139	25139
R^2	0.8390	0.8393

Note: This table presents the results of the DID estimates of the effect of Basel III regulations and the overnight RRP facility on trading relationship strength of RRP-ineligible MMFs and dealers, as measured by the TRV. TRV is calculated based on the dollar amount of transactions between the two parties. t-ratios reported in parentheses are calculated using standard errors clustered at the relationship level.

Table 10: Effects of Regulations on TRF: RRP-eligible MMFs and dealers

	(1) Eligible MMF	(2) Eligible MMF
EUD x Sep 23, 2013	-0.001	-0.001
	(-0.23)	(-0.09)
EUD x Dec 23, 2013	0.001	0.003
	(0.15)	(0.30)
EUD x Implemented	0.013	0.012
	(1.36)	(1.37)
TRF (t-1)	0.705***	0.699***
	(21.27)	(21.43)
Time FE	Yes	Yes
Relationship FE	Yes	Yes
Controls x Implemented	No	Yes
Observations	16515	16515
R^2	0.8499	0.8504

Note: This table presents the results of the DID estimates of the effect of Basel III regulations and the overnight RRP facility on trading relationship strength of RRP-eligible MMFs and dealers, as measured by the TRF. TRF is calculated based on the frequency of transactions between the two parties. t-ratios reported in parentheses are calculated using standard errors clustered at the relationship level.

Table 11: Effects of Regulations on TRF: RRP-ineligible MMFs

	(1) Ineligible MMF	(2) Ineligible MMF
EUD x Sep 23, 2013	-0.006	-0.006
	(-1.58)	(-1.62)
EUD x Dec 23, 2013	-0.007	-0.007
	(-1.10)	(-1.14)
EUD x Implemented	-0.014**	-0.014**
	(-2.05)	(-2.12)
TRF (t-1)	0.761***	0.758***
	(36.08)	(37.37)
Time FE	Yes	Yes
Relationship FE	Yes	Yes
Controls x Implemented	No	Yes
Observations	25139	25139
R^2	0.9060	0.9062

Note: This table presents the results of the DID estimates of the effect of Basel III regulations and the overnight RRP facility on trading relationship strength of RRP-ineligible MMFs and dealers, as measured by the TRF. TRF is calculated based on the frequency of transactions between the two parties. t-ratios reported in parentheses are calculated using standard errors clustered at the relationship level.