Finance and Economics Discussion Series
Divisions of Research & Statistics and Monetary Affairs
Federal Reserve Board, Washington, D.C.

Monetary Policy Implementation and Private Repo Displacement: Evidence from the Overnight Reverse Repurchase Facility

Alyssa G. Anderson and John Kandrac

2016-096

Please cite this paper as:
Anderson, Alyssa G., and John Kandrac (2016). "Monetary Policy Implementation and Private Repo Displacement: Evidence from the Overnight Reverse Repurchase Facility," Finance and Economics Discussion Series 2016-096. Washington: Board of Governors of the Federal Reserve System, https://doi.org/10.17016/FEDS.2016.096.

Monetary Policy Implementation and Private Repo Displacement: Evidence from the Overnight Reverse Repurchase Facility

Alyssa G. Anderson* *Federal Reserve Board*

John Kandrac‡ *Federal Reserve Board*

October 31, 2016

ABSTRACT

In recent years, the scale and scope of major central banks' intervention in financial markets has expanded in unprecedented ways. In this paper, we demonstrate how monetary policy implementation that relies on such intervention in financial markets can displace private transactions. Specifically, we examine the experience with the Federal Reserve's newest policy tool, known as the overnight reverse repurchase (ONRRP) facility, to understand its effects on the repo market. Using exogenous variation in the parameters of the ONRRP facility, we show that participation in the ONRRP comes from substitution out of private repo. However, we also demonstrate that cash lenders, when investing in the ONRRP, do not cease trading with any of their dealer counterparties, highlighting the importance of lending relationships in the repo market. Lastly, using a confidential data set of repo transactions, we find that the presence of the Fed as a borrower in the repo market increases the bargaining power of cash lenders, who are able to command higher rates in their remaining private repo transactions.

JEL classification: G23, E52, G11, E58

Keywords: repo, money market mutual funds, monetary policy, Federal Reserve

*Board of Governors of the Federal Reserve System. E-mail: alyssa.g.anderson@frb.gov. Tel.: +1 202 973 6967.

‡Board of Governors of the Federal Reserve System. E-mail: john.p.kandrac@frb.gov. Tel.: +1 202 912 7866.

We are grateful for helpful comments from Sriya Anbil, Jim Clouse, Jane Ihrig, Elizabeth Klee, Marco Machiavelli, Bernd Schlusche, Rebecca Zarutskie, members of the Money Markets Workgroup for the Federal Reserve System's Long-Run Monetary Policy Implementation Framework, and seminar participants at the Federal Reserve Board and the Federal Reserve Bank of New York. We thank Michelle Bongard for excellent research assistance. The views expressed in this paper are solely the responsibility of the authors and should not be interpreted as reflecting the views of the Board of Governors of the Federal Reserve System or of anyone else associated with the Federal Reserve System.

1. Introduction

The rise of shadow banking over the last couple of decades has significantly changed the nature of financial intermediation in United States. In particular, entities beyond banks, including money market funds (MMFs) and securities dealers have become increasingly important financial intermediaries. Additionally, a rise in the importance of many types of collateral-backed funding has accompanied the expansion of the shadow banking sector (Di Maggio and Tahbaz-Salehi (2014)). For instance, the repo market is a primary source of short-term funding for dealers, and a large component of MMFs' investment portfolios. However, the expansion of nonbank financial intermediation evidently came with attendant risks to financial stability, which were revealed throughout the most recent financial crisis. For example, a run in the repo market contributed importantly to the severity of the crisis (Gorton and Metrick (2012)) and, as the turmoil spread, eventually resulted in a temporary federal guarantee of the systemically important MMF industry.

In its response to the financial crisis, the Federal Reserve (the Fed) established a number of unprecedented facilities to provide liquidity to key credit markets. Additionally, in response to the continued sluggish economic recovery in the aftermath of the crisis, the Fed extended its intervention in financial markets by engaging in a series of quantitative easing (QE) programs. Indeed, in the years since the crisis, many central banks resorted to similar measures in an effort to buoy local economies. One consequence of this aggressive central bank intervention has been a rapid expansion in monetary authorities' asset holdings and presence in financial markets. Figure 1 plots the size of major central banks' balance sheets relative to GDP over the past ten years. Nearly a decade removed from the start of the financial crisis, central banks around the world continue to maintain an outsized presence in financial markets.

The current abundance of liquidity prevents the Fed from exerting control over the federal funds rate—its main policy instrument—in the traditional manner, which relied on tight control

over the supply of reserves held by the banking system. In the current environment, modest changes in the supply of reserves will have no effect on the effective federal funds rate.[1]

In order to raise short-term rates in this new environment, the Fed has again waded into financial markets in unprecedented ways. One important aspect of this intervention entailed broadening the Fed's set of counterparties beyond depository institutions and primary dealers to include many participants in the shadow banking sector. Further, in September 2013 the Fed introduced the standing Overnight Reserve Repurchase (ONRRP) facility, explaining that it would be used to help control short-term interest rates in a context of excessive liquidity. Under the ONRRP facility, money market participants including MMFs, GSEs, banks, and dealers can enter into reverse repurchase agreements with the Fed at a prespecified fixed rate. In these transactions, counterparties lend cash to the Fed overnight, with Treasury securities from the Fed's portfolio posted as collateral. In order to gain operational experience with the ONRRP, the Fed conducted daily tests of the ONRRP facility for a period of more than two years. Over this time, the Fed occasionally adjusted parameters of the facility, such as the fixed offer rate and the maximum counterparty bid amount, or "cap." As shown in Figure 2, participation in the ONRRP facility has often reached sizeable levels, with a peak of $424 billion in December 2015.

In this paper, we analyze the effects of the ONRRP facility—the Fed's newest monetary policy tool—by examining the facility's influence on both MMF investment decisions and the highly important tri-party repo market.[2] By design, the cash that flows into the ONRRP must come from some other segment of the market. We exploit exogenous changes in the terms of the ONRRP facility during its testing phase to identify the substitution between private repo activity and the ONRRP. During the testing operations, some MMFs faced a constrained investment allocation decision due to the ONRRP facility's maximum daily counterparty cap, while others were unconstrained by the cap. Subsequent cap increases precipitated substantial increases in ONRRP investment for previously-constrained MMFs, and provide events around which we con-

[1] See Ihrig et al. (2015) for a description of monetary policy implementation before and after the crisis.

[2] The tri-party repo market is one segment of the total repo market. For more information, see Section 2.2.

struct difference-in-difference (DD) estimates of the effect of increased ONRRP participation on alternative MMF investments.

Using regulatory filings, we find that, given the presence of the ONRRP, MMFs invest less in private repo transactions backed by both Treasury and agency collateral, while also reducing their investment in deposits held with banks. However, cash lenders in the tri-party repo market evidently value their dealer relationships highly enough to maintain their relationships with all dealers. This result is consistent with the importance of relationships in the repo market described in Copeland et al. (2012). Therefore, despite the fact that cash is shifted out of the repo market, the market's structure is largely unaffected by the ONRRP. In a separate analysis using confidential transaction-level tri-party repo data, we examine the effects of the ONRRP facility on money funds' bargaining power. We show that an exogenous positive shock to a fund's ability to invest in the ONRRP facility improves their bargaining power relative to dealers, thereby supporting private repo rates.

This study relates to two distinct strands of literature. First, we contribute to the literature that seeks to further understand the dynamics of the repo market. In particular, many studies have documented the growing reliance on the repo market for short-term funding, as well as the role of the repo market in the recent financial crisis (Gorton and Metrick (2012); Copeland et al. (2014b); Krishnamurthy et al. (2014)). Here, we consider the effects of a standing monetary policy tool that introduces the Fed as a large, persistent repo borrower willing to expand the supply of a safe asset to a variety of money market participants, and show the resulting effects on tri-party repo volumes and rates.

Second, we demonstrate how monetary policy implementation can displace activity in private financial markets. Some evidence points to central banks crowding out private transactions, particularly during periods of heavy intervention or acute market strain. For example, Brunetti et al. (2011) present results that suggest ECB intervention during the financial crisis crowded out interbank trades. In additional analysis of ECB actions both before and during the European sovereign debt crisis, de Andoain et al. (2016) show that ECB liquidity injections displace pri-

vate activity in the euro area, notably reducing interbank trading. Separately, Kandrac (2016) documents that Federal Reserve purchases under quantitative easing programs displaced private activity in the secondary market for mortgage-backed securities. Although crowding out private financial market transactions is commonly thought to degrade liquidity, market functioning, and/or price discovery, the ultimate effects of disintermediating private activity by a standing repo facility are uncertain. For instance, a standing facility may increase the likelihood or severity of flight-to-safety "runs" in the repo market if investors suddenly become reluctant to lend to non-Fed counterparties (Frost et al. (2015)). Conversely, if the ONRRP facility crowds out privately-issued repo created by the shadow-banking sector, it can buttress financial stability by reducing the externalities associated with a large private repo market, which—as demonstrated by the recent financial crisis—is subject to highly disruptive runs (Stein (2012); Carlson et al. (2014); Greenwood et al. (2015)). In addition to crowding out risky private repo, the ONRRP, by providing an interest-bearing near-money asset to a broad array of counterparties, could help reverse the absorption of safe assets during QE (BIS (2015), Gorton (2016),Infante (2016)) and potentially lower liquidity premia (Nagel (2014)).

The remainder of this paper proceeds as follows: Section 2 provides institutional background on the Fed's ONRRP facility and the tri-party repo market. Section 3 explains how we use the exogenous changes in the facility's parameters to identify causal effects of Fed intervention on the repo market. Section 4 discusses our data sets and presents summary statistics, while Section 5 discusses our empirical methodology and results. Section 6 concludes.

2. Institutional Background

2.1. The Federal Reserve's ONRRP Facility

In the wake of the 2007-2009 financial crisis, the Federal Reserve has greatly expanded its balance sheet as a result of several rounds of asset purchase programs known as QE. Consequently, banks now have large amounts of excess reserve balances on deposit with the Fed. Given that monetary policy implementation before the crisis relied on scarce reserves to influence short-term rates, the

Fed decided to employ new tools to conduct monetary policy in the current environment (Ihrig et al. (2015)). The primary tool, interest on excess reserves (IOER), was implemented in October 2008. In theory, banks should be unwilling to lend at less than IOER, the deposit rate which they can earn from the Fed, causing IOER to set a floor on short-term interest rates. However, in the United States, there are many non-bank participants in money markets that do not have access to IOER and are therefore willing to lend at lower rates. As a result, the Fed responded in two ways - first, by expanding the set of counterparties with which it transacts and second, by introducing the ONRRP facility.

As early as October 2009, the Fed was considering using repo transactions as a means of withdrawing policy accommodation, while also expanding the set of eligible repo counterparties to broaden the reach of such transactions (FRBNY (2009)). Specifically, RRP operations have been made available to money market funds (MMFs), government-sponsored enterprises (GSEs), and banks, as well as the Fed's traditional counterparties, primary dealers. Market participants could apply to become a Fed counterparty in several rounds since March 2010.[3]

In September 2013, subsequent to the expansion of the Fed's RRP eligible counterparties, the Fed began conducting regular overnight, fixed-rate capped-allotment reverse repurchase agreements (ONRRP) through an extended testing exercise. In these repo transactions, the Fed borrows from a broad set of counterparties on an overnight basis using Treasury securities as collateral.[4] At the program's start, 140 counterparties were eligible to participate in the ONRRP, including MMFs, GSEs, banks, and primary dealers.[5] Importantly, by making the ONRRP available to a broad set of counterparties, the ONRRP should help establish a firmer floor on short-term rates, in contrast to IOER, which can only be offered to depository institutions. Since these nonbank counterparties can now lend to the Fed at the ONRRP offering rate, they should be unwilling to lend in the market at any rate below the ONRRP rate. As a result of successful

[3]See `www.newyorkfed.org/markets/rrp_eligibility_criteria.html` for a description of the current eligibility requirements for MMFs, GSEs, and banks.

[4]See Frost et al. (2015) for a complete discussion of the design of the ONRRP.

[5]Subsequently, other counterparties have become eligible. See `www.newyorkfed.org/markets/expanded_counterparties.html` for a full list of the current eligible counterparties.

testing, the FOMC's Policy Normalization Principles and Plans, released in September 2014, states the Committee's intention to use the ONRRP facility as a supplementary tool to help control the federal funds rate during the normalization of the stance of monetary policy.[6]

Since its inception, MMFs have been the dominant users of the ONRRP. Figure 2 shows the ONRRP takeup of MMFs through 2015. The ONRRP has a maximum bid for each individual counterparty. As shown in Figure 3, this maximum has ranged from $500 million at the start of the program to $30 billion currently. The maximum individual bid is the primary constraint for participants.[7]

2.2. The Tri-party Repo Market

In the U.S., the repo market is divided into several segments, including the bilateral repo market, the tri-party repo market, and the GCF market, which is a subset of tri-party.[8] Given data limitations, a precise estimate of the size of the repo market and its sub-components is not attainable. However, it is estimated that the tri-party market accounts for about 40-45 percent of the repo market, or about $1.5 trillion per day in 2014 and 2015 (Copeland et al. (2014a); Baklanova et al. (2015)).

The tri-party market relies on two third-party clearing banks that settle all repo transactions. Tri-party market transactions typically consist of nondealers, including MMFs, securities lenders, and others, lending to dealers. MMFs conduct all of their repo lending in the tri-party market and account for about a third of daily tri-party volume. Tri-party collateral is specified only by type, not specific security; that is, it is a general collateral market. Fedwire-eligible collateral, including Treasuries, agency debt, and agency mortgage-backed securities (MBS), account for about 85 percent of market volume as of 2012 (Copeland et al. (2012)).

[6] See "Policy Normalization Principles and Plans," September 2014, `www.federalreserve.gov/newsevents/press/monetary/20140917c.htm`.

[7] The ONRRP also had an aggregate cap of $300 billion between September 22, 2014 and December 16, 2015. Before and after that period, there was no aggregate cap. However, the cap was reached only once, on September 30, 2014.

[8] In the bilateral market, cash providers and cash borrowers trade directly. Bilateral repo typically consists of interdealer trading or dealers borrowing from hedge funds. Conversely, the GCF (General Collateral Finance) market is a blind-brokered interdealer market that is a subset of the broader tri-party market. For a complete description of the U.S. repo market, see Copeland et al. (2012).

We limit our attention to the tri-party repo market only in this paper for two reasons. First, all Federal Reserve ONRRP operations are conducted in the tri-party market. Second, our primary focus is on the response of MMF repo activity, which also takes place over the tri-party platform, to the ONRRP.

3. Identification Strategy

In general, our aim is to evaluate the effects of the Fed's ONRRP facility on the private repo market. Because the ONRRP is a standing facility, repo investors (such as MMFs and government-sponsored entities) can choose at will to invest risklessly with the central bank at the facility's rate rather than with their usual dealer counterparties. Even without actual participation in the facility by ONRRP counterparties, the mere presence of the facility could boost MMF's bargaining power vis-à-vis dealers, thereby exerting upward pressure on repo and other short-term rates. However, as demonstrated in Figure 2, MMFs evidently found that the terms offered by the ONRRP facility presented an attractive investment opportunity, and did indeed participate in the facility, possibly at the expense of existing counterparties. In Figure 4, we show total MMF repo investment composition, subdivided into Fed and private components. Ostensibly, total MMF repo investment remained roughly constant over the last four years, and the entrance of the Fed claimed market share from MMF's private counterparties.

Of course, participation in the ONRRP facility is an endogenous outcome of borrower and lender interactions in money markets. Consequently, other factors may have reduced dealers' willingness or ability to borrow in the repo market. For example, regulatory pressures on dealers including more stringent capital requirements, the introduction of the liquidity coverage ratio, and less permissive rules regarding the netting of repo trades may have reduced dealers' willingness to borrow in the repo market. In addition, as previously seen in Figure 4, total private tri-party repo declined starting in January 2013 when the supplementary leverage ratio was implemented internationally. As a result of these changes, increases in MMF ONRRP participation may only be coincidentally timed with a reduction in private repo, which could simply reflect ongoing

changes in the market that are unrelated to the introduction of the ONRRP facility. In other words, it may be that MMFs participate in the ONRRP differentially as a *result* of their available options in money markets, thereby introducing bias in attempts to estimate the effect of ONRRP participation on investment outcomes of Fed counterparties.

In order to overcome these endogeneity issues and draw causal inference, we exploit exogenous variation in the ONRRP facility parameters, which were adjusted relatively frequently during the testing phase. In particular, we focus on the changes to the counterparty caps that regulated the maximum daily bid of individual counterparties. As shown in Figure 3 and discussed in the previous section, the counterparty cap was raised in increments over the first year of the ONRRP's existence. Funds that would have optimally invested more in the ONRRP facility than permitted by the maximum bid amounts were thus forced to invest at the maximum bid. Evidently facing a constrained investment decision, these funds should be expected to boost their ONRRP investment upon an increase in the counterparty cap. Importantly, the maximum bid amounts were raised merely as a normal result of the expansion of the ONRRP tests, and were unrelated to any changes in either the repo market or MMF investment decisions and preferences. Thus, MMFs that were previously constrained by the counterparty cap experienced an exogenous change in their ability to invest in the ONRRP facility. These MMFs compose our "treatment" group.[9] By comparing treated funds to ONRRP-eligible MMFs that were not constrained by the counterparty caps—our "control" group—we are able to generate differences-in-differences (DD) estimates of the effect of an increase in ONRRP participation.

Figure 5 depicts an illustrative example of our identification strategy. In period 1, on the left side of the figure, the counterparty cap does not constrain fund 1, which is able to achieve its optimal investment allocation. Fund 1 is an example of a control group fund. Funds 2 and 3, however, face a binding counterparty cap in the first period. In period 2—the beginning of the "post-treatment" period—the counterparty cap has been increased, affording funds 2 and 3 the

[9]In results presented in Section 5, we show that previously-constrained funds did in fact significantly increase their ONRRP investment after an increase in the maximum bid amount.

ability to increase their ONRRP investment, while fund 1 continues to submit below-cap bids. Thus, funds 2 and 3 will compose our treatment group. As portrayed in the figure, in period 2, the maximum allowable bid is increased by an amount large enough to leave fund 2 unconstrained by the new cap, while fund 3 remains constrained by the new, higher cap. Although we consider both funds 2 and 3 to have received treatment as a result of the cap increase, we differentiate between two types of treatment: one treatment group transitions from a constrained state to a constrained state despite the higher cap, while the other treatment group transitions from a constrained state to an unconstrained state. Eventually, all treated funds in our sample enter the unconstrained treatment group, as depicted in period 3, when the counterparty cap is increased to a level allowing fund 3 to achieve an unconstrained investment allocation.

Employing such a DD identification strategy addresses many threats to the casual interpretation of our results. First, DD allows us to account for constant differences between funds, as well as any overarching factors that could affect the whole repo market at any point in time. That is, our DD estimation controls for differences between treated and control MMFs and between quarter-ends. Moreover, the time variation in our treatment implies that other explanations of the effects we observe require a time pattern that is well correlated with the timing of cap increases and affect only those funds that were subject to the binding cap increase. Given the exogenous nature of the cap changes, this seems unlikely. In addition, we note that the tri-party repo market introduces frictions that can limit alternate sources of within-fund variation over time, particularly as it concerns each MMF's set of borrowers. For instance, as described in Copeland et al. (2012), each MMF must execute a master repo agreement with each individual borrower, which lays out important elements of their repo transactions. Before tri-party repo trading can commence, each MMF-borrower pair must additionally execute a unique custodial undertaking agreement with the clearing bank to establish its role as the agent. Lastly, most repo transactions are overnight trades, and many of these are open transactions between a given borrower and lender that are continuously "rolled over" on a day-to-day basis. Thus, MMFs can only transact with those dealers with which they have executed the necessary agreements,

and trading conventions in the repo market ensure that MMF-dealer trading relationships are relatively persistent.

We follow the general DD identification strategy outlined above throughout the remainder of the paper. Summary statistics for our treatment and control groups follow in Section 4 and the details of the precise DD specifications are provided in Section 5.

4. Data

In order to evaluate the effect of the ONRRP facility on MMFs, we employ two data sets. First, we use the monthly MMF filings of form N-MFP to the Securities and Exchange Commission, which contain a schedule of portfolio holdings for each MMF.[10] Federal Reserve counterparty eligibility was determined by an application process available to all qualifying funds. In order to avoid any pollution from possible selection issues emanating from the application decision, we limit our sample to eligible counterparties.

A second data set is required to analyze rates in the tri-party repo market. For this analysis, we turn to a confidential data set that contains daily transactions in the tri-party repo market.[11] Our data comprise daily trades aggregated to the mutual fund complex ("family") level reported to the Federal Reserve Bank of New York (FRBNY) by one of the two clearing banks in the tri-party market. Trade information includes the volume, the annualized rate, the term to maturity, the identity of the dealer and lender, and the underlying collateral backing each repo transaction. For our purposes, we exclude term trades and retain only those transactions backed by Fedwire-eligible Treasury and agency (including agency MBS and agency debt) collateral. Neither of these filters significantly reduces our sample size, as overnight trades backed by Treasury or agency collateral compose over 70 percent of the transactions in our tri-party data.

Summary statistics for both treated (ever constrained) and control (never constrained) MMFs are shown in Table 1. Since most of our analysis is conducted using quarter-end observa-

[10] U.S. Securities and Exchange Commission, N-MFP data, `www.sec.gov/edgar.shtml`

[11] While the actual dataset we use is confidential, aggregate information on triparty repo activity can be found at `www.newyorkfed.org/banking/tpr_infr_reform_data.html`.

tions when ONRRP participation is typically highest, all values are reported as of June 28, 2013, the last quarter-end before the ONRRP began. Over our sample period (December 2012 to June 2015), there are a total of 107 ONRRP-eligible MMFs.[12] As reported in the first row of Table 1, we find that about 40 percent of these 107 funds are included in our treatment group. 36 percent of MMFs were constrained by the $1 billion counterparty cap imposed on September 30, 2013, while the $3 billion cap imposed on December 31, 2013 constrained about a quarter of the funds in the sample.

The two types of money funds in our sample, government-only and prime, each compose about half of the treatment group that at some point faced a binding counterparty cap. However, the control group has a relatively larger share of prime funds than the treated group does.

Treatment and control MMFs have no statistically significant differences in their dealer relationships. In particular, they are similar in their average number of dealers, percentage of lending to foreign dealers, riskiness of dealers (as measured by CDS spreads), concentration of lending across dealers (as measured by HHI), and share of the largest dealer.[13] We take particular note of the groups' similarity in their exposure to foreign dealers. Given geographical differences in the implementation of the Basel leverage ratio requirement, foreign dealers contract their repo borrowing on quarter-ends more so than domestic dealers do.[14] Therefore, it may be that constrained funds are simply those funds that trade more with large, foreign dealers, which borrow less on quarter-ends, forcing their MMF lenders to go to the ONRRP. However, this does not seem to be the case given the similar dealer profiles of the two groups.

The next two rows show that the treatment and control groups also receive the same rates in their tri-party repo transactions, both overall and in Treasury collateral repo only.

However, the two MMF groups do differ in their size and asset allocation. Specifically, treated funds tend to be larger in terms of assets under management (AUM) and invest a relatively

[12] We exclude the relatively few eligible funds classified as "tax-exempt."

[13] See Section 5.2 for definitions of weighted CDS spreads and HHI.

[14] Countries differ on the time frame over which the leverage ratio is calculated. In the U.S., the leverage ratio is based on a daily average across a quarter, while in the Eurozone, it is based on the value on the quarter-end day only. Other foreign regions have intermediate calculation time frames. The treatment and control funds also have no difference in the percentage of their lending specifically to Eurozone dealers (not shown).

larger share of their assets in both Treasury and, to a lesser extent, agency repo. On the other hand, control funds are more likely to invest in commercial paper. It seems reasonable that funds that both have more assets to invest and are more active in the repo market would be larger participants in the ONRRP and therefore more likely to be constrained by the individual counterparty caps.

5. Methods and Results

In the subsections below, we describe the specific data and DD specifications used to obtain results that address three distinct questions regarding the effects of the Fed's ONRRP facility. In Section 5.1, we examine whether and to what extent MMFs shift investments from other asset categories to the ONRRP. After demonstrating that MMFs substitute between the ONRRP and private repo, Section 5.2 considers the effect of this substitution on MMFs' dealer relationships. In order to invest more with the Federal Reserve, MMFs may turn away from some counterparties, and transact with fewer dealers. However, we find that the value of lending relationships in the repo market is high enough to prevent MMFs from dropping any of their dealer counterparties. Finally, Section 5.3 demonstrates that the ONRRP facility confers bargaining power on MMFs, thereby increasing dealer funding costs.

5.1. Effects of ONRRP Participation on MMF Asset Allocation

Our first goal is to estimate asset substitution effects in order to determine which money markets experience a withdrawal of funding when MMFs invest in the ONRRP facility. The data used for this analysis come from the quarter-end MMF filings of form N-MFP, discussed in Section 4. By aggregating MMF securities holdings from the N-MFP into distinct investment categories, we are able to track fund-level asset allocation over time, which we can then relate to changes in ONRRP participation. For this analysis, we sample the MMF asset portfolio holdings on quarter-end dates between December 2012 and June 2015.

Table 2 reports average asset class holdings as a percent of total AUM for the sample of all ONRRP-eligible MMF counterparties classified as either prime or government-only funds. The column on the left reports MMF's asset shares as of Q3 2013, a few days after the introduction of the ONRRP facility. Summing the asset class shares reveals that the asset categories we consider account for about 85 percent of total AUM for MMFs in our sample. By Q3 2014, shown on the right of Table 2, there was a statistically significant reduction in the shares of MMF portfolios invested in Treasury debt, Treasury-collateral repo, and agency-collateral repo. As mentioned earlier, the especially large proportional declines in repo investments (about 44 and 38 percent for Treasury and agency repo, respectively) came amid regulatory pressures that have led to an overall reduction in dealer balance sheets, limiting their participation in the repo market. Even outside of these regulatory issues, other factors causing MMFs' planned or forced reductions in other asset classes could at least partly determine ONRRP participation. Consequently, an estimate of the substitution effects *induced* by ONRRP participation requires an identification strategy—such as the one described in Section 3—that relies on an exogenous change in MMFs' ability or willingness to participate in the facility.

In order to generate a DD estimate of these substitution effects, we compare a control group of funds that were never constrained by the ONRRP counterparty cap to a treatment group of funds that faced a binding cap at some point. Since the cap was increased between each quarter-end, treated funds may no longer face a binding counterparty cap, or they could increase their ONRRP investment to such an extent that they are still bound by the new (higher) cap. Specifically we estimate regressions of the following form:

$$\begin{aligned} y_{it} = \delta \cdot (\text{PreviouslyBound}_i \cdot \text{Unbound}_{it}) + \rho \cdot (\text{Bound}_{it-1} \cdot \text{Bound}_{it}) + \\ \beta_i \cdot \text{MMF}_i + \gamma_t \cdot \text{Quarter}_t + \varepsilon_{it}, \end{aligned} \tag{1}$$

$$\text{where} \qquad y_{it} = 100 \cdot \frac{\text{AssetClass}_{it}}{\text{AUM}_{it}}$$

In equation (1), $\text{PreviouslyBound}_i \cdot \text{Unbound}_{it}$ identifies our main treatment group, taking a value of one for funds that previously faced a binding counterparty cap, but are not bound by the cap in quarter t. All treated funds eventually enter this group.[15] Thus, δ is the DD estimate of the marginal effect of increased ONRRP participation owing to an increase of the counterparty cap to a point at which it becomes non-binding and the MMF faces an unconstrained investment decision. However, some funds may continue to face a constraint even after the counterparty cap has been lifted. These funds nevertheless witness a sharp increase in ONRRP participation as a result of the exogenous cap increase, and therefore we include an additional treatment group, indicated by the $\text{Bound}_{it-1} \cdot \text{Bound}_{it}$ dummy, which takes a value of one for funds that remained bound by the cap following an increase. Similar to δ, ρ estimates the marginal effect of ONRRP participation as a result of an increase in the counterparty cap, although ρ measures the effect for funds in periods during which they continue to face a binding cap and hence a constrained investment decision. By Q3 2014, the counterparty cap was increased to its current level of $30 billion, which was evidently large enough to provide all MMFs with an unconstrained investment allocation decision as no funds submitted bids at the cap.

Additionally, equation (1) includes fund fixed effects, as well as a full set of time fixed effects. Because an MMF's total size may partially determine whether the counterparty cap is binding, we include MMF's pre-treatment AUM in some specifications as a robustness check, interacted with a "post-treatment" dummy that takes a value of one after September 2013.[16] Standard errors in equation (1) are clustered at the fund complex level (Bertrand et al. (2004)).

In Figure 6, we show evidence of parallel trends in the asset shares between those funds that were never constrained by the counterparty caps and those that were. Although the patterns in Figure 6 suggest the parallel trends assumption is not violated, we nevertheless include a robustness check that allows us to relax the parallel trends assumption as follows:

[15] There are almost no examples of funds that transition back to a bound state after a cap increase has left them unbound.

[16] We note, however, that size of an MMF is not an absolute predictor of whether a fund found the counterparty cap binding. In fact, 8 of the largest 20 MMFs in our sample (including the largest fund) did not bid at the $1 billion counterparty cap on September 30, 2013. Our results are nearly identical if we simply control for AUM by including the lagged value for all funds in all time periods.

$$y_{it} = \delta \cdot (\text{PreviouslyBound}_i \cdot \text{Unbound}_{it}) + \rho \cdot (\text{Bound}_{it-1} \cdot \text{Bound}_{it}) + \\ \lambda_i \cdot (\text{MMF}_i \cdot t) + \beta_i \cdot \text{MMF}_i + \gamma_t \cdot \text{Quarter}_t + \varepsilon_{it} \tag{2}$$

In this specification, we add fund-specific time trends in order to capture any possible temporal divergence in asset shares between treatment and control funds. Although the additional fund-level trends can weaken our results if the treatment effect emerges gradually over time, we prefer to include this robustness check in light of our relatively long sample period. Though MMFs' asset mix does not typically change dramatically on a day-to-day basis, shifts in fund manager preferences or the market environment may eventually cause some funds to shift their investment mix over time.

Table 3 reports results from estimating the specifications described above. Turning to the most basic specification in column 1, we see that the coefficients on the treatment dummies for the Fed RRP dependent variable verify the effect of treatment on MMF ONRRP investment. On average, an increase in the maximum counterparty cap led to previously-bound MMFs increasing their investment in the ONRRP facility by about 8.8 and 6.5 percent of assets for our two treatment groups.

For the next outcome variable—the share of assets invested in private Treasury-backed repo—we find that MMFs substitute out of private repo transactions in order to invest with the Fed. This asset category is likely the closest substitute for the ONRRP facility, as ONRRP loans are also backed by Treasury collateral. The substitution out of Treasury repo for both treatment groups further underscores the substitutability of these transactions for ONRRP investment.

Agency repo investments also fall for MMFs in our main treatment group, but appear insensitive to cap increases when funds remain bound by the new counterparty caps. Comparing against the previous results for Treasury-backed repo transactions, this suggests that MMFs only substitute away from agency-backed repo after they have substituted away from other asset categories first. In other words, a fund that remains constrained by the larger counterparty cap

will shift out of Treasury repo first, but as the cap is increased enough for the fund to find itself unconstrained, it will eventually begin to shift investment away from agency repo as well.

Deposits show a similar pattern to Treasury repo, though the point estimates imply a reduction in deposits as a share of assets of 2.25 percentage points when the counterparty cap is increased. The results are evident for both treatment groups, suggesting that money funds are willing to move funds out of short-term deposits in order to invest in a reverse repo with the Fed. Summing the coefficient estimates over these four asset categories reveals that the full increase in the ONRRP facility for both treatment groups is offset by reductions in Treasury repo, agency repo, and deposits.

Dividing the point estimates of the effects on these asset classes by the estimated increase in the ONRRP investment yields rates of substitution between the ONRRP and other assets. For example, using the point estimates for the Unbound_{it} treatment group in our baseline specification reported in column (1), we find that an increase in ONRRP investment of 1% of AUM corresponds to reductions in treasury repo, agency repo, and deposits of about 0.45%, 0.30%, and 0.25%, respectively. Naively applying these figures to the $167 billion MMFs invested in Fed RRP on Dec 31, 2014 implies that private tri-party Treasury collateral repo volume was lower by $75 billion (roughly 11% of the traded volume on that day), and agency collateral repo was lower by $50 billion (or 9% of the traded volume). Reductions in deposits driven by the ONRRP investment represent a far smaller share of the overall deposit market.

The remaining asset classes show no statistically significant response to increases in the maximum bid amount, with point estimates that generally lie close to zero. Very similar results are presented in columns 2 through 4—which add controls for fund size and/or fund-level trends—although the deposits result weakens somewhat in certain specifications. In unreported results, we find that a weighted least squares estimator yields identical conclusions.

Overall, these results show that the Fed's ONRRP facility creates substitution from private investments in Treasury repo, agency repo, and deposits. However, it is unclear what the potential effects of this substitution may be. The funding that is withdrawn from dealers and banks as a

result of the ONRRP could potentially be worrisome to a central bank that seeks to minimize its presence in financial markets. Moreover, the existence of the Fed's ONRRP facility may increase the likelihood of a shift in risk sentiment spurring a flight-to-quality with MMFs flocking to the Fed's ONRRP facility (Frost et al. (2015)).[17] In such an event, substitution out of other asset classes such as commercial paper could emerge, starving regular funding from an additional class of borrowers. Conversely, crowding out privately-issued repo may ameliorate overall financial stability by reducing the externalities associated with a large private repo market that is prone to runs (Carlson et al. (2014), Frost et al. (2015)).

To further support the interpretation of the estimated causal effects reported above, we conduct two separate placebo tests. Our first test includes a placebo treatment dummy that takes a value of one for previously-constrained funds in the quarter immediately after they become unconstrained. In the context of the stylized example presented in Figure 5, this dummy would be zero for Fund 2 until the third period. For Fund 3, this placebo treatment would be zero until period 4 (not shown). Since these funds were unconstrained by the counterparty cap in the period prior to the placebo treatment, we should expect a null result. However, if previously-constrained funds were merely in the process of shifting their asset allocation for a reason unrelated to the increases in the ONRRP caps, we would expect to see statistically significant effects similar to our estimated treatment effects.

In Panel A of Table 4, we report the results of this placebo test for the asset categories for which we found evidence of substitution. Comparing the point estimates for the Placebo_{it} treatment group with the Unbound_{it} treatment group, we can see that funds that become unconstrained do not differentially increase their ONRRP participation in the periods after the cap no longer binds the funds' investment decision. Therefore, it does not appear that our results are driven by other factors, such as an uneven withdrawal of dealer borrowing that disproportionately affected the funds in our treatment group.

[17] The total investment in the ONRRP would be constrained by the designated aggregate and counterparty caps, which could be changed in the future.

Panel B of Table 4 presents the results of a second placebo test. In this test, we use an 11 quarter sample period (the same length as that used in our main analysis in Table 3) that ends in June 2013, the quarter immediately prior to the introduction of the ONRRP. In this exercise, our placebo treatment dummy takes a value of one for the treated funds in our sample as of December 2011.[18] As demonstrated in Panel B, there is no evidence of differential investment in Treasury repo, agency repo, or deposits. Thus, these results confirm that there are no systematic differences in investment patterns between the treatment and control MMFs that are driven by causes other the changing availability of the ONRRP. Moreover, because this sample period spans the period before the introduction of the ONRRP, these results offer further evidence of parallel trends in the asset shares between the two groups of funds.

5.1.1. Robustness Using Trade-Level Data

In the remainder of the paper, we focus solely on the effects of the Fed's ONRRP facility on the repo market. In this sub-section, we establish the robustness of the substitution effects of the ONRRP outlined above for both Treasury and agency-backed repo. If the substitution results achieved in section 5.1 were driven by the trading pattern exhibited by only those dealers that borrowed from funds in our treatment group, our main results would disappear. For example, treated funds may trade with dealers that are winding down their repo positions more rapidly than control funds' dealers do. Similarly, treated funds may also trade more heavily with certain foreign dealers, who, as discussed above, withdraw more heavily from the repo market on quarter-ends.[19] Therefore, treated funds may be forced to invest in the ONRRP more than their control fund counterparts in response to their respective dealers, which could bias our estimated treatment effects. However, it is important to note that treated and control funds trading with different sets of dealers is not necessarily sufficient for our results to be biased. Rather, treated funds'

[18]This placebo treatment date is chosen to correspond to the first post-treatment period of our baseline results (December 2013). However, the results of this exercise are not sensitive to the choice of hypothetical treatment date.

[19]However, as noted in Section 4, treated and control funds have similar relationships with foreign dealers.

dealers also need to disproportionately pull back from the repo market after the introduction of the ONRRP and in conjunction with the timing of the increases in the ONRRP cap.

In order to address these concerns, we construct a panel of borrower-lender pairs using the data available in the N-MFP reports. By identifying the dealer counterparty to each repo transaction, we are able to then control for the borrower-specific demand for repo (Khwaja and Mian (2008)). Thus, estimating variants of the following regression specification on quarter-ends allows us to address potential threats to the causal estimates reported above.

$$\begin{aligned} y_{ijt} = {} & \delta \cdot (\text{PreviouslyBound}_i \cdot \text{Unbound}_{it}) + \rho \cdot (\text{Bound}_{it-1} \cdot \text{Bound}_{it}) + \\ & \lambda_{ij} \cdot (\text{MMF-Dealer}_{ij} \cdot t) + \phi_{jt} \cdot (\text{Dealer}_j \cdot \text{Quarter}_t) + \beta_{ij} \cdot \text{MMF-Dealer}_{ij} + \\ & \gamma_t \cdot \text{Quarter}_t + \varepsilon_{it} \end{aligned} \tag{3}$$

In equation (3), y_{ijt} represents the asset share of the day t repo activity between MMF i and dealer j. Notably, we are now able to control for trends in activity between individual trading partners ($\text{MMF-Dealer}_{ij} \cdot t$), as well as dealer-specific behavior in each quarter ($\text{Dealer}_j \cdot \text{Quarter}_t$). As shown in Table 5, the conclusions remain identical even when accounting for the extent to which dealer behavior can explain the results. Comparing the sign and significance for both Treasury repo (Panel A) and agency repo (Panel B) to the results in Table 3, we see the results are nearly identical. Of course, the magnitude of the coefficients is somewhat lower, as we are now estimating the effects of treatment on *trade-level* asset substitution. These results strongly support our earlier interpretation that MMFs in fact substitute out of private repo in favor of the ONRRP.

5.2. Effects of ONRRP Participation on Dealer Relationships

Next, we consider how the changes in MMF asset allocation seen in the previous section affect funds' relationships with dealers in the tri-party repo market. We again look at quarter-end MMF repo activity from the N-MFP data between December 2012 and June 2015. In particular, we focus on four measures of MMF lending relationships: number of dealers, weighted CDS

spread, HHI (Herfindahl index), and share of lending to the largest dealer. Number of dealers is simply the total number of dealers that a fund trades with on a given quarter-end date. As funds substitute into the ONRRP and away from private repo, they may do so either by dropping certain counterparties or by simply reducing their volume with one or several of their existing counterparties.

Weighted CDS spread measures the volume-weighted CDS spread of all J dealers with which fund i trades.[20] It is defined as:

$$\text{Weighted CDS Spread}_{it} = \frac{\sum_{j=1}^{J} \text{CDS Spread}_{jt} \cdot \text{Repo Volume}_{ijt}}{\text{Repo Volume}_{it}} \tag{4}$$

Funds that substitute more cash into the ONRRP may differentially substitute away from certain dealers. In particular, they may substitute away from low-risk dealers since they are the most direct substitute for the Fed, which is a risk-free counterparty. Alternatively, they may substitute away from their higher-risk dealers in an effort to reduce their overall risk profile, although, as documented by Krishnamurthy et al. (2014), repo funding with Treasury and agency collateral appears less sensitive to dealers' perceived default risk.

HHI is a measure of concentration among a funds' counterparties. It is defined as:

$$\text{HHI}_{it} = \sum_{j=1}^{J} \left[\frac{\text{Repo Volume}_{ijt}}{\text{Repo Volume}_{it}} \right]^2 \tag{5}$$

HHI ranges from $1/J$ to 1, with lower values representing less concentration among dealers whereas higher values correspond to lending that is concentrated among just a few dealers. Lastly, we examine the share of lending to a fund's largest dealer, calculated simply as the percentage of each MMF's total repo volume that is transacted with the dealer to which it lends most heavily. These last two measures are used to assess whether MMFs differentially substitute away from dealers based on the volume traded between the pair.

For each of the four measures of dealer relationships, we consider MMFs' Treasury- and

[20] CDS data are provided by Markit (IHS Markit Ltd. "Markit Credit Default Swaps Data." `wrds-web.wharton.upenn.edu/wrds/`).

agency-collateral repo activity separately. There may be stronger results for Treasury repo since, as seen in the previous section, the substitution effects are stronger for Treasury repo. For each of our measures of counterparty relationships, we present evidence of parallel trends in Figure 7, and proceed by estimating the following regression:

$$\begin{aligned} y_{it} = \delta \cdot (\text{PreviouslyBound}_i \cdot \text{Unbound}_{it}) + \rho \cdot (\text{Bound}_{it-1} \cdot \text{Bound}_{it}) + \\ \lambda_i \cdot (\text{MMF}_i \cdot t) + \beta_i \cdot \text{MMF}_i + \gamma_t \cdot \text{Quarter}_t + \varepsilon_{it}, \end{aligned} \tag{6}$$

$$\text{where} \qquad y_{it} \in \Big\{ \text{Number of Dealers}_{it}, \text{Weighted CDS Spread}_{it}, \text{HHI}_{it}, \text{Share Largest Dealer}_{it} \Big\}$$

The results are shown in Table 6. There are no statistically significant differences in either the number of dealers or the weighted CDS spread. This suggests that MMFs continue trading with all of their original counterparties and do not differentially substitute away from or toward riskier dealers, consistent with the patterns shown in Krishnamurthy et al. (2014).[21] In unreported results, we confirm that MMFs are not likely to sever dealer relationships by estimating the probability of a trade between the unique dealer-fund trading pairs in our sample. We find that, after a counterparty cap increase, previously-bound funds are no less likely to conduct a trade with one of their trading partners than funds that were never constrained by the cap. However, there is some significance in the regressions for HHI and the share of the largest dealer, especially when fund trends are included in Panel B, with consistently negative point estimates throughout. Thus, funds' dealer-concentration HHIs fall as funds become less constrained by the ONRRP cap.

In Section 5.1, we demonstrated that funds' repo volume decreases in response to the ONRRP, while we show here that the number of repo borrowers does not change. Therefore, the HHI results suggest that MMFs appear to be substituting away from those counterparties with which they trade the most, while preserving dealer relationships even for those dealers that

[21] This analysis was also conducted over the days around each cap change using daily repo position data described in Section 5.3. Similarly, no significant differences in the number of dealers or weighted CDS spread were found.

account for only a small share of total trading volume. This interpretation is consistent with the decrease in the share of lending to a fund's largest counterparty. Consequently, MMF participation in the ONRRP results in a more even distribution of private repo investment. Together, these results suggest that lending relationships are very important in the repo market and MMFs have a desire to maintain their relationships with dealers. In particular, funds do not drop any of their dealer counterparties and do not differentially substitute away from dealers according to their risk of default. Rather, MMFs adjust trading volume across their existing counterparties by substituting away from their largest counterparties to some degree. Importantly, the results of this analysis suggest that, despite the ONRRP taking volume from the private repo market, it does not significantly affect the relationship structure of MMFs and dealers in the tri-party repo market.

5.3. Effects of ONRRP Participation on Repo Rates

In our next exercise, we aim to identify the effects of the ONRRP on prevailing rates in the repo market. By providing repo investors with credible outside options, MMFs eligible for the ONRRP should be put in a more advantageous bargaining position vis-à-vis dealers. Of course, funds that are investing in the ONRRP facility at the counterparty cap do not possess an option to invest a marginal dollar in the ONRRP facility at the expense of dealer-provided repo. Therefore, we again exploit the exogenous increases in counterparty caps, because these increases should bestow additional bargaining power on MMFs that were previously investing the maximum-allowable amount at the ONRRP.

The data used for this analysis come from the confidential transaction-level tri-party data from FRBNY discussed in Section 4. Repo activity is aggregated to unique MMF family-dealer-collateral triples. Since there may be many trades on a given day between MMFs and their dealers, we calculate both the weighted average rate between the MMF and dealer for a given collateral type, as well as the volume-weighted 25th and 75th percentile rates.

To identify the effect of the potentially increased bargaining power MMFs command in the

private repo market, we again appeal to a DD strategy. Specifically, we identify fund families in which at least one MMF was bound by the counterparty cap on the day before a cap increase. The first four counterparty cap increases, which occurred on the following dates, witnessed at least one bound fund family on the day before the change: September 27, 2013; December 23, 2013; January 30, 2014; and March 5, 2014.[22,23] Multiple fund families contain MMFs that were seemingly constrained by the counterparty cap in all but the final date (March 5, 2014), when only a single fund family faced a binding constraint immediately prior to the cap increase.

We then compare changes in rates for previously-constrained MMFs to previously-unconstrained funds on the day of a counterparty cap increase by estimating the following regression:

$$\begin{aligned}\text{RepoRate}_{ijct} = \delta \cdot (\text{CapIncrease}_t \cdot \text{Bound}_{it-1}) + \beta_{ijc} \cdot (\text{MMF Family}_i \text{Dealer}_j \text{Collateral}_c) + \\ \gamma_t \cdot \text{Day}_t + \varepsilon_{ijct}\end{aligned} \tag{7}$$

In equation (7), δ is the DD estimate of the effect of a cap increase on previously-bound funds' weighted average repo rate (with a given dealer). For simplicity, and because most funds did not face a binding counterparty cap on the day of the cap increases, we consider only a single treatment group that is composed of fund families that were bound the day prior to the increase.[24] If MMFs' bargaining power sufficiently increases upon counterparty cap increases, δ would be expected to be positive, indicating an increase in the rate that MMFs can command when presented with the outside option. Similarly, δ could also be positive if money funds simply shift lower-rate private transactions to the ONRRP facility, though the ability of dealers to pay a rate below the ONRRP indicates a differential in bargaining power that favors dealers.[25] Figure 8 demonstrates parallel trends in the daily average repo rates earned by constrained and

[22] In each case, the announcement of the increase in the maximum counterparty bid amount was announced on the business day prior to the change.

[23] Because the cap was increased monotonically, trades by previously-constrained funds generally declined over time as a share of total trades. After collapsing trades to family-dealer-collateral triples, we find that the percent of trades attributable to the previously-constrained cohort were, respectively, 23%, 28%, 15%, and 9%.

[24] Though power is decreased, we find very similar results when separating the treatment group into funds that were unconstrained on the day of the cap increase and funds that remained bound by the cap.

[25] Some funds have more limited outside options than others. For example, government-only MMFs face more investment restrictions than prime MMFs due to their prospectus.

unconstrained fund families in the week leading up to the changes in the ONRRP maximum bid amount. There is no apparent divergence in advance of any of the cap changes in our sample.

The left side of Table 7 reports the estimate of δ from a regression with the weighted average repo rate used as the dependent variable. Panel A reports the results around the first cap change only, with the subsequent panels adding observations around other cap increases, as indicated. Specification (1) includes only the day before and the day of the counterparty cap increase, and shows a robustly positive effect of an increase in ONRRP participation on the rates that previously-constrained funds command in private repo transactions. The coefficient of 0.26 in Panel A implies that the first cap increase led to an increase in previously-constrained funds' average repo rate of 0.26 basis points. Although this increase appears small, the average tri-party repo rate (including both Treasury and agency collateral) was only 3 basis points on the day before the cap increase, according to the publicly available BNY Mellon Tri-Party Repo Indices. The result that the ONRRP appears to increase repo rates by offering an outside option to money funds is consistent with the findings of Han and Nikolaou (2016).

The second column of Table 7—labeled (2)—extends the pretreatment period to include the five trading days prior to the change in the counterparty cap, for a total of six days, and shows a very similar pattern upon an increase in the maximum bid. To avoid any potentially confounding effects of the announcement of the cap increase, which occurred one business day before each cap increase, specification (3) excludes the announcement day from the six-day window used in column (2). Although the announcement occurs during the trading day prior to the cap increase, it generally occurred after most private repo activity had taken place. Thus, it is unsurprising that the five day results excluding the announcement day are consistent with the six day sample presented in column (2). Panels B through D show that these results persist when the sample is expanded to include the days around other cap changes. Including the final cap increase in the sample (Panel D) produces less precise estimates, but this may be attributable to the fact that most complexes did not face a binding cap during this episode, and thus contains very few trades associated with treated funds.

In the memorandum items in the middle and right side of Table 7, we report the effect of the cap increase on the weighted 25th and 75th percentile of fund families' rate distribution. As expected, the cap increase has a somewhat larger effect on lower-rate trades. In total, the results reported in Table 7 are consistent with the hypothesis that the outside option presented by the ONRRP increases repo lenders' bargaining position vis-à-vis borrowers.[26] Therefore, as a result of the ONRRP facility, dealers not only witnessed a reduction in the supply of funds as shown in section 5.1, but also faced marginally higher funding costs.

6. Conclusion

In this paper, we conduct an analysis of the effects of the Fed's newest monetary policy tool, the ONRRP facility, which works through regular intervention in the repo market. Specifically, we exploit exogenous changes in an MMF's ability to invest in the Fed's ONRRP facility to identify substitution away from private repo transactions and into repo investment with the Fed. Further analysis of the pattern of MMF substitution shows that, rather than severing trades with certain dealers entirely, money funds withdraw from their dealer counterparties in a roughly even fashion, albeit with somewhat more withdrawal from larger counterparties. This pattern of substitution likely reflects MMFs' desire to preserve existing lending relationships, highlighting the importance of these relationships in the repo market. Finally, we use confidential data on trades in the tri-party repo market to show that the ONRRP facility bestows additional bargaining power on MMFs. When MMFs are able to invest in the ONRRP, rates on private repo transactions increase. Thus, the presence of the Fed as a borrower in the repo market not only reduces funding from dealers, but also leads to marginally higher dealer funding costs.

More broadly, this study demonstrates how the implementation of monetary policy—particularly when it relies on a large presence in financial markets—can reduce private activity in funding markets. Many central banks have enlarged their presence in financial markets as a

[26]The finding that Fed intervention can increase repo rates also accords with Fleming et al. (2010), who show that the Term Securities Lending Facility (TSLF)—a temporary emergency response to the developing financial crisis in 2008—resulted in higher repo rates. However, the TSLF boosted repo rates by mitigating acute shortages of Treasury collateral, whereas the ONRRP evidently works through increased bargaining power.

consequence of the drastic expansion of the scale and scope of monetary intervention in financial markets since the recent crisis. As we have begun to show in this paper, asset substitution engendered by the implementation of monetary policy may have implications for collateral assets and privately-intermediated trading activity.

References

Baklanova, Viktoria, Adam M. Copeland, and Rebecca McCaughrin, 2015, Reference guide to US repo and securities lending markets, FRBNY Working Paper.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan, 2004, How much should we trust differences-in-differences estimates?, *Quarterly Journal of Economics* 119, 249–275.

BIS, 2015, Central bank operating frameworks and colalteral markets, Committee on the global financial system markets committee *Bank for International Settlements*.

Brunetti, Celso, Mario Di Filippo, and Jeffrey H. Harris, 2011, Effects of central bank intervention on the interbank market during the subprime crisis, *Review of Financial Studies* 24, 2053–2083.

Carlson, Mark, Burcu Duygan-Bump, Fabio Natalucci, William R. Nelson, Marcelo Ochoa, Jeremy Stein, and Skander Van den Heuvel, 2014, The demand for short-term, safe assets and financial stability: Some evidence and implications for central bank policies, Finance and Economics Discussion Series, Working Paper.

Copeland, Adam, Isaac Davis, Eric LeSueur, and Antoine Martin, 2014a, Lifting the veil on the U.S. bilateral repo market.

Copeland, Adam, Darrell Duffie, Antoine Martin, and Susan McLaughlin, 2012, Key mechanics of the U.S. tri-party repo market, *FRBNY Economic Policy Review* 18, 17–28.

Copeland, Adam, Antoine Martin, and Michael Walker, 2014b, Repo runs: evidence from the tri-party repo market, *Journal of Finance* 69, 2343–2380.

de Andoain, Carlos Garcia, Florian Heider, Marie Hoerova, and Simone Manganelli, 2016, Lending-of-last-resort is as lending-of-last-resort does: Central bank liquidity provision and interbank market functioning in the euro area, *The Journal of Financial Intermediation* .

Di Maggio, Marco, and Alireza Tahbaz-Salehi, 2014, Financial intermediation networks, Columbia Business School Research Paper.

Fleming, Michael J., Warren B. Hrung, and Frank M. Keane, 2010, Repo market effects of the term securities lending facility, *The American Economic Review* 100, 591–596.

FRBNY, 2009, Operating policy: Statement regarding reverse repurchase agreements.

Frost, Josh, Lorie Logan, Antoine Martin, Patrick McCabe, Fabio Natalucci, and Julie Remache, 2015, Overnight RRP operations as a monetary policy tool: Some design considerations, Finance and Economics Discussion Series, Working Paper.

Gorton, Gary, and Andrew Metrick, 2012, Securitized banking and the run on repo, *Journal of Financial Economics* 104, 425–451.

Gorton, Gary B., 2016, The history and economics of safe assets, *National Bureau of Economic Research* .

Greenwood, Robin, Samuel G. Hanson, and Jeremy C. Stein, 2015, A comparative-advantage approach to government debt maturity, *The Journal of Finance* 70, 1683–1722.

Han, Song, and Kleopatra Nikolaou, 2016, Trading relationships in the OTC market for secured claims: Evidence from triparty repos, Board of Governors of the Federal Reserve System.

Ihrig, Jane, Ellen Meade, and Gretchen Weinbach, 2015, Rewriting monetary policy 101: What's the fed's preferred post-crisis approach to raising interest rates?, *Journal of Economic Perspectives* 29, 177–198.

Infante, Sebastian, 2016, Private money creation with safe assets and term premia, Finance and Economics Discussion Series, Working Paper.

Kandrac, John, 2016, The costs of quantitative easing: liquidity and market functioning effects of Federal Reserve MBS purchases, Board of Governors of the Federal Reserve System.

Khwaja, Asim Ijaz, and Atif Mian, 2008, Tracing the impact of bank liquidity shocks: Evidence from an emerging market, *American Economic Review* 98, 1413–1442.

Krishnamurthy, Arvind, Stefan Nagel, and Dmitry Orlov, 2014, Sizing up repo, *The Journal of Finance* 69, 2381–2417.

Nagel, Stefan, 2014, The liquidity premium of near-money assets, *National Bureau of Economic Research* .

Stein, Jeremy C., 2012, Monetary policy as financial stability regulation, *Quarterly Journal of Economics* 127, 57–95.

Figure 1. Central bank assets to GDP. This figure shows the time path of central banks' assets as a percent of GDP. Sources: Board of Governors of the Federal Reserve System, Factors Affecting Reserve Balances, H.4.1, Table 8; European Central Bank, Consolidated Financial Statement of the Eurosystem, Table 1.1; Bank of Japan, Bank of Japan Accounts; Bank of England, Central Bank's Balance Sheet, Table B1.1.1. Note: Beginning in October 2014, the BoE no longer accounts for liquidity support operations in its balance sheet.

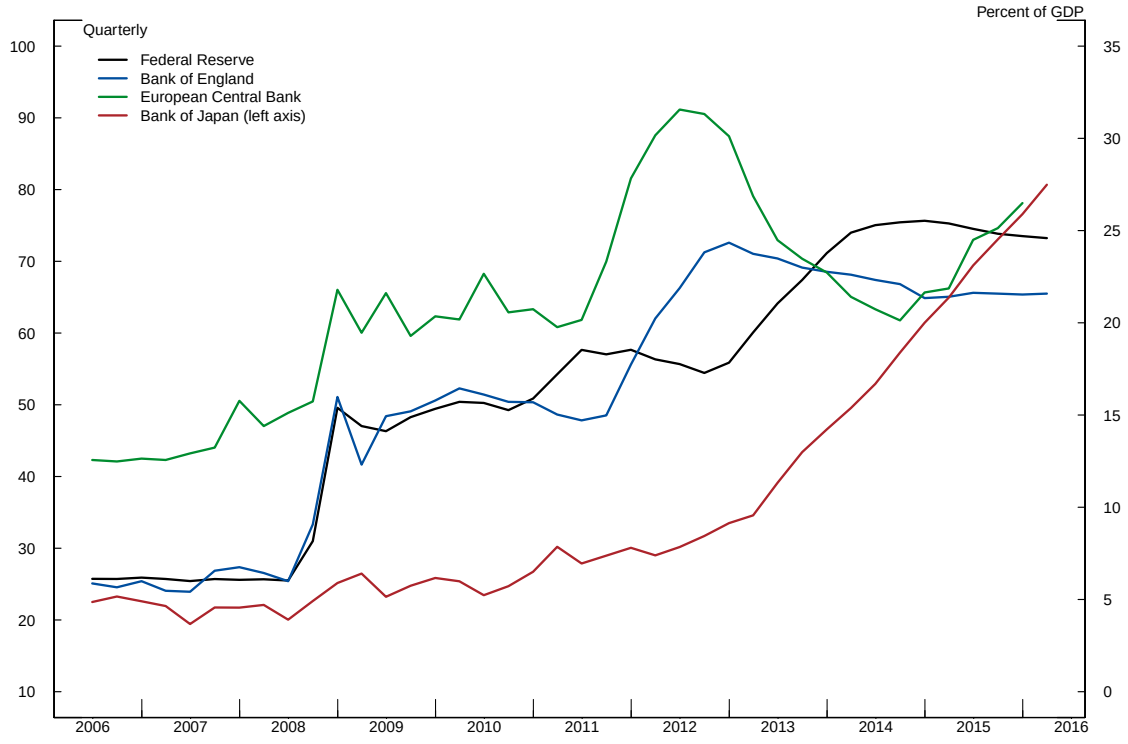

Figure 2. Money market mutual funds' investment in the ONRRP facility. This figure shows MMFs' daily participation in the ONRRP facility since its inception (other counterparty types not shown. Source: Federal Reserve Bank of New York, 2013-2015, Reverse Repo Data.

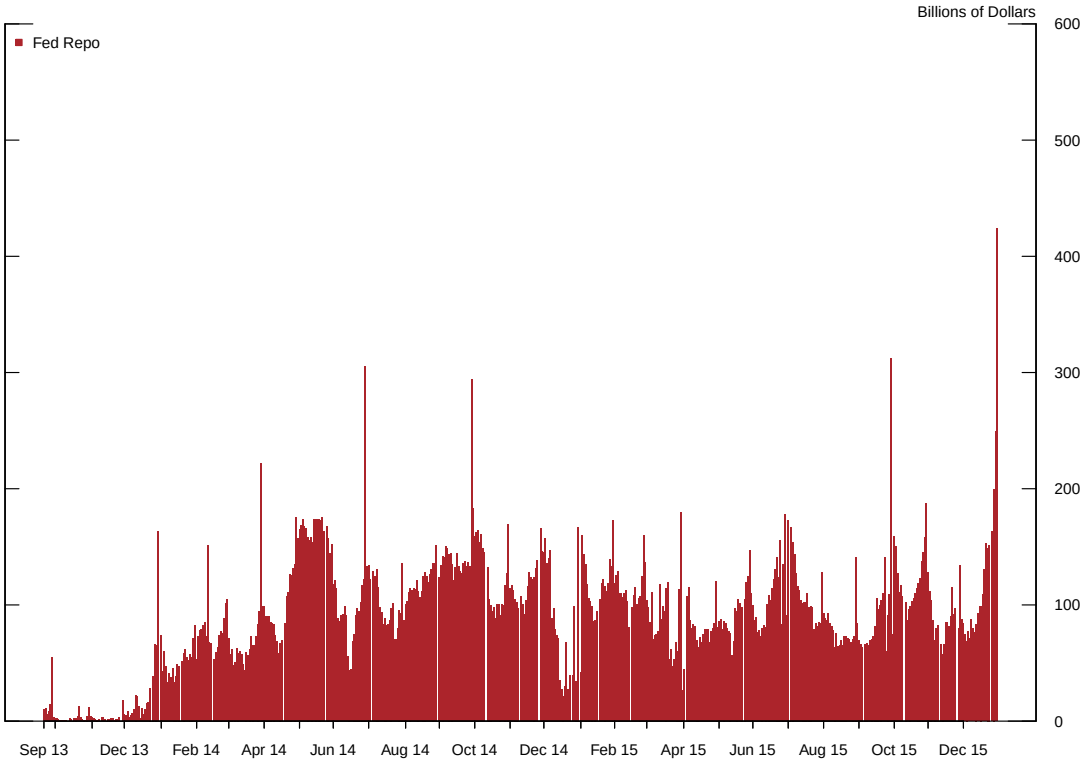

Figure 3. ONRRP counterparty caps. This figure shows the time path of changes in maximum ONRRP bids allowed per counterparty.

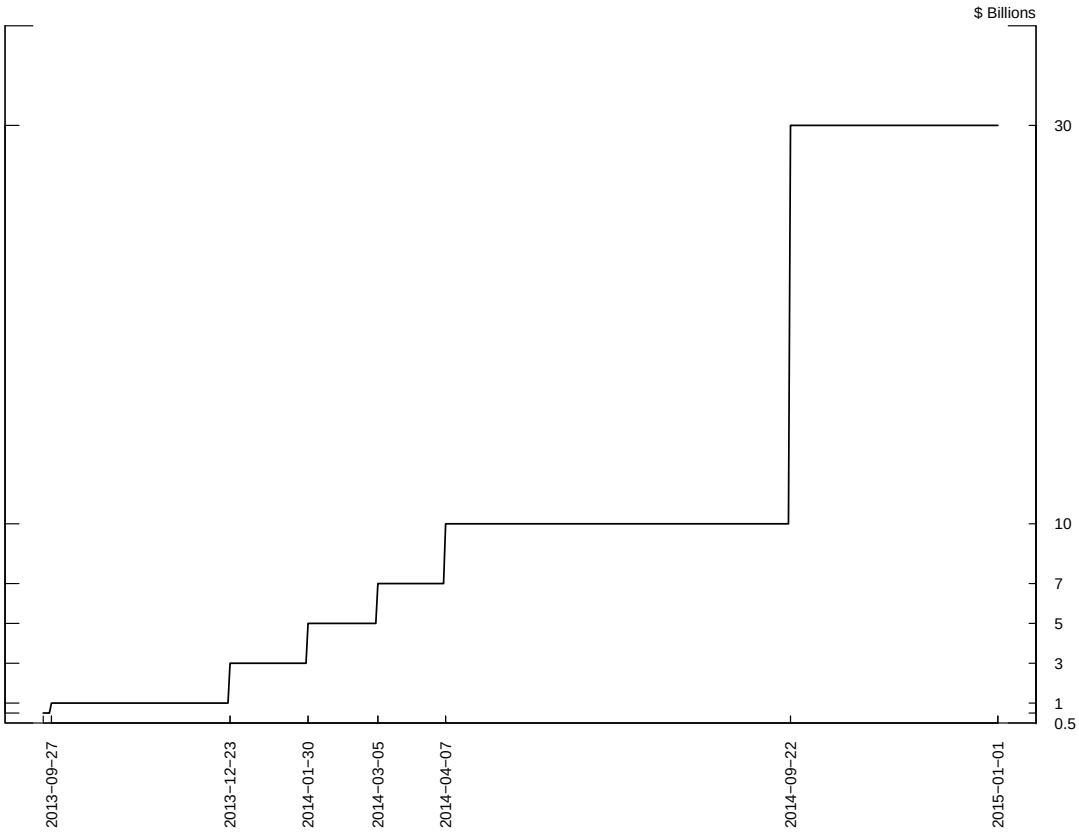

Figure 4. Money market mutual fund repo investment. This figure shows the monthly private versus Fed decomposition of MMF repo investment backed by Treasury and agency collateral. Source: SEC form N-MFP.

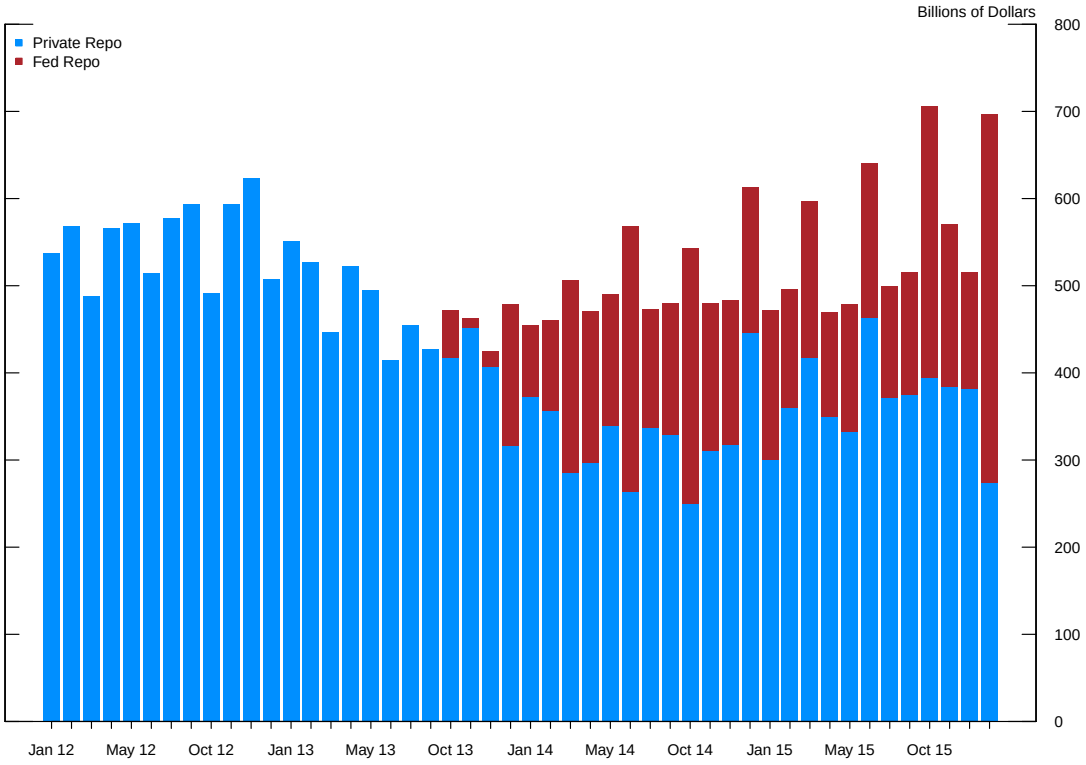

Figure 5. Example of control and treatment groups. This figure depicts an illustrative example of our identification strategy. In the first period, fund 1 (yellow) does not face a constrained investment allocation decision as a result of the counterparty cap (the dashed line), and is included in the control group. Funds 2 and 3 (red and blue, respectively) are bound by the cap, and will compose the treatment groups. In the second period, fund 2 now faces an unconstrained investment decision as a result of the increase in the counterparty cap, and is thus included in the $Unbound_2$ treatment group. Although fund 3 was able to increase its ONRRP investment as a result of the increase in the counterparty cap in period 2, it continues to face a constrained investment decision, and is thus included in the $Bound_2$ treatment group. In period 3, the counterparty cap is again increased, with all funds facing an unconstrained investment decision such that fund 3 joins the $Unbound_3$ treatment group with fund 2.

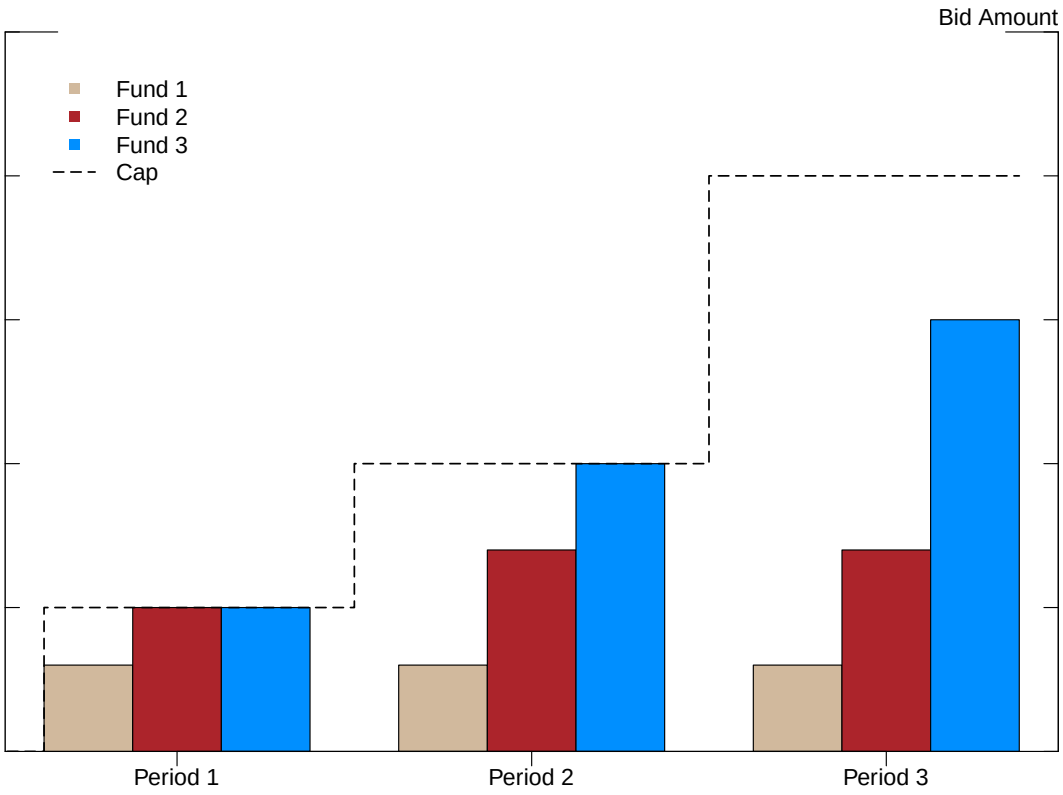

Figure 6. Trends in asset shares. This figure presents the difference of changes in asset shares between control and treated MMFs in the six quarters prior to implementation of the ONRRP. Thus, a positive value corresponds to quarters in which control funds witness asset shares rising more (or falling less) than the asset share for treatment funds. A negative value corresponds to quarters in which control funds witness asset shares rising less (or falling more) than the asset share for treatment funds.

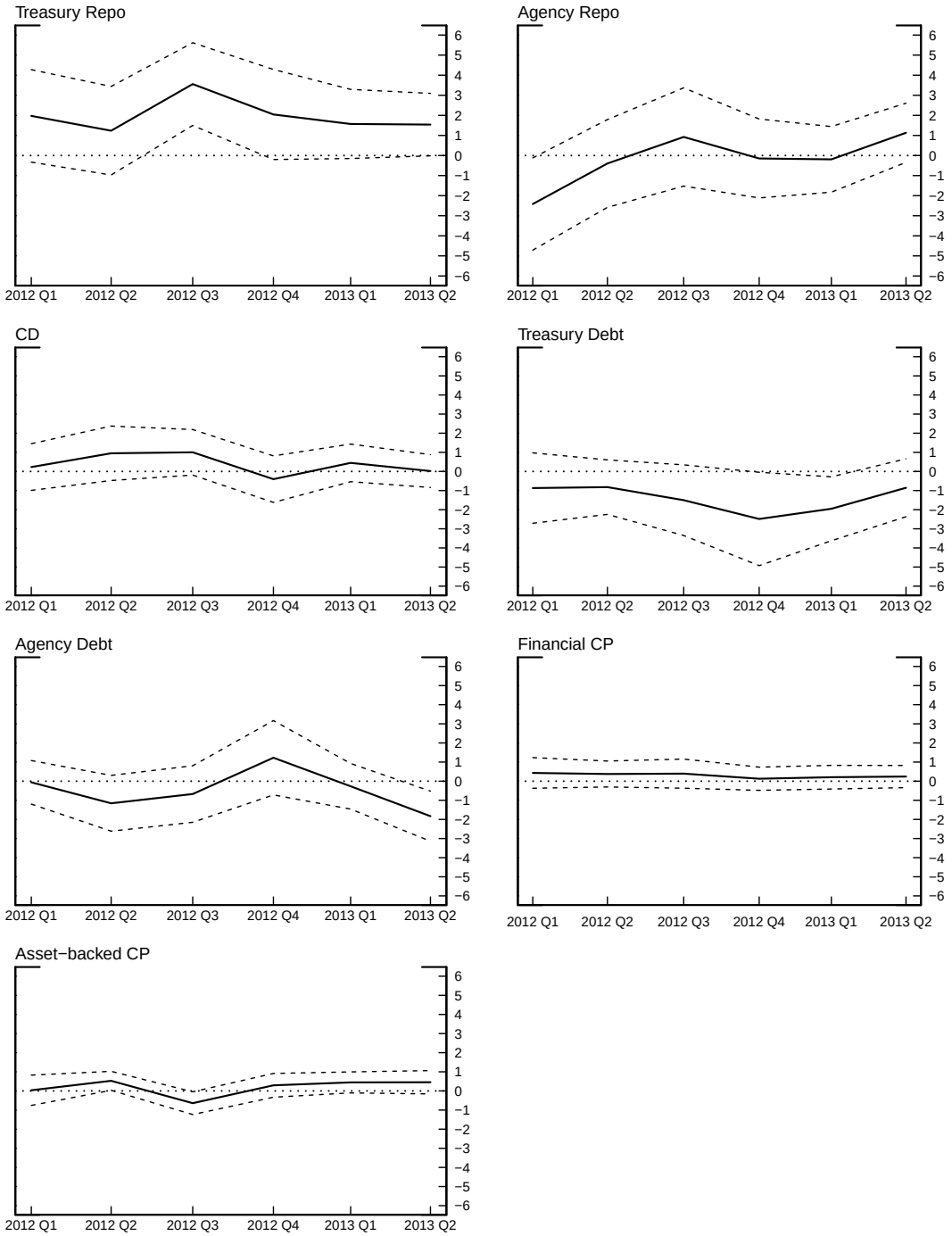

Figure 7. Trends in measures of counterparty relationships. This figure presents the difference of changes in measures of counterparty relationships between control and treated MMFs in the six quarters prior to implementation of the ONRRP. Thus, a positive value corresponds to quarters in which control funds witness counterparty relationship measures rising more (or falling less) than the measure for treatment funds. A negative value corresponds to quarters in which control funds witness counterparty relationship measures rising less (or falling more) than that of treatment funds.

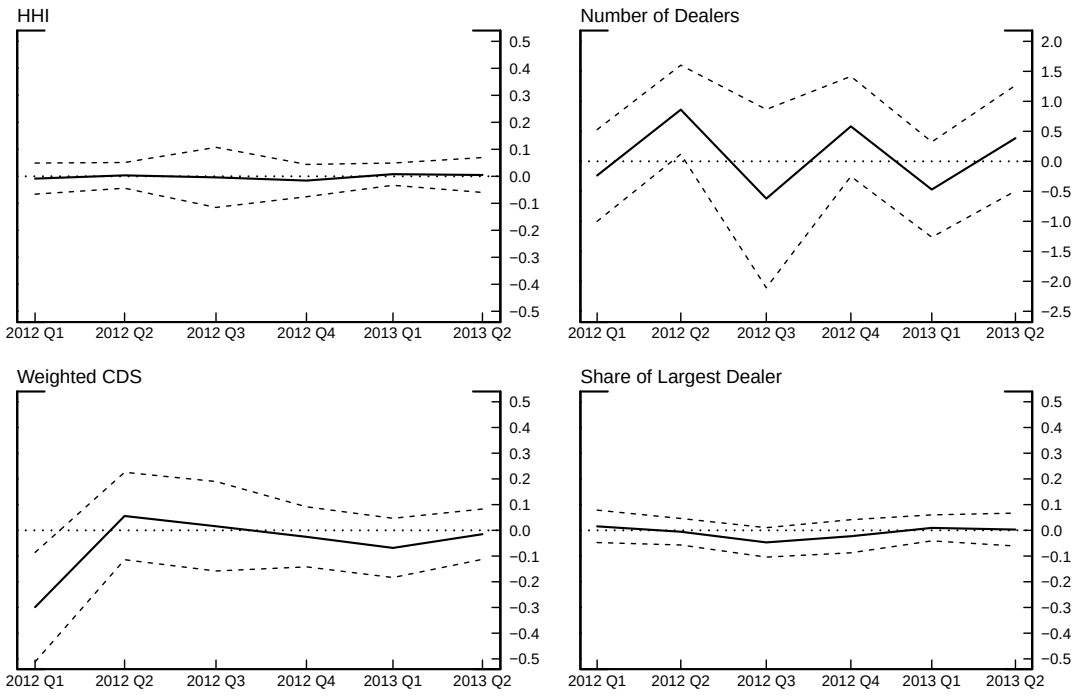

Figure 8. Trends in rates on private repo transactions. This figure presents the difference of changes in weighted average rates between control and treated MMFs in the six quarters prior to implementation of the ONRRP. Thus, a positive value corresponds to quarters in which control funds witness average rates rising more (or falling less) than the rate for treatment funds. A negative value corresponds to quarters in which control funds witness average rates rising less (or falling more) than rates for treatment funds.

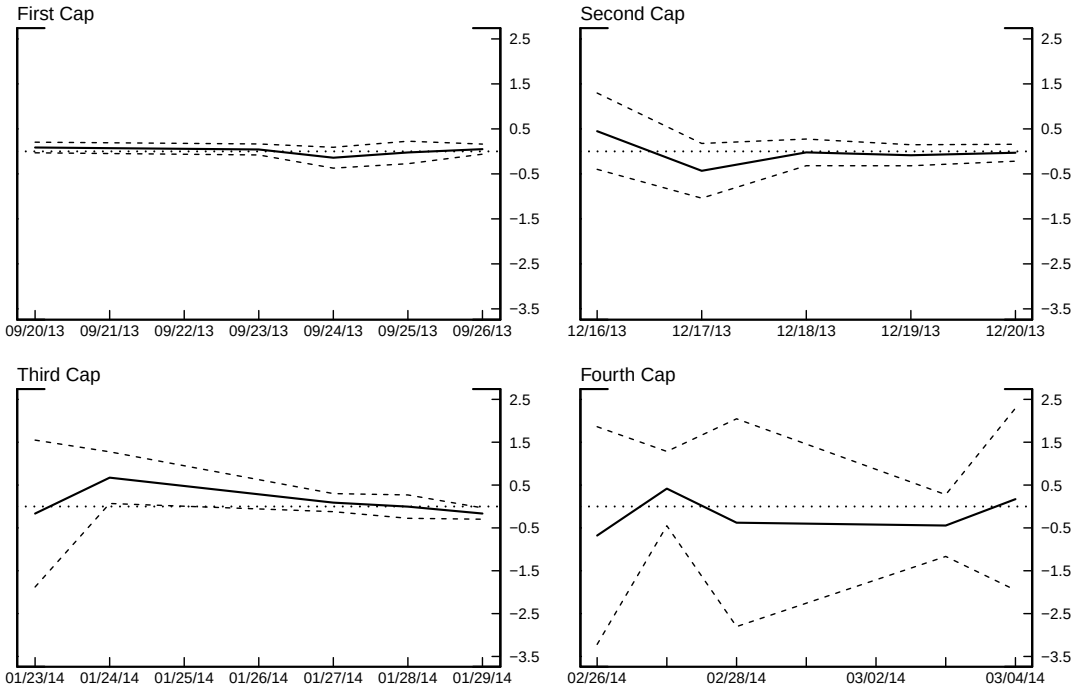

Table 1
Summary Statistics

Variable	Treated (Ever Constrained)	Control (Never Constrained)
Number of Funds	45	62
Number of Prime Funds	23	45
Number of Dealers per Fund	9.38	8.28
	(0.72)	(0.64)
% of Foreign Dealers per Fund	61.10	60.96
	(4.14)	(3.50)
Weighted CDS Spread (%)	0.85	0.83
	(0.06)	(0.04)
HHI	0.18	0.20
	(0.03)	(0.03)
Share of Largest Dealer	0.25	0.28
	(0.03)	(0.03)
Weighted Treas/Agency Repo Rate (bps)	13.38	11.62
	(1.23)	(0.84)
Weighted Treasury Repo Rate (bps)	10.38	10.02
	(0.38)	(0.02)
AUM ($, billions)	27.1	14.4***
	(2.89)	(2.68)
Treasury Repo (% of AUM)	15.12	5.97**
	(3.45)	(1.68)
Agency Repo (% of AUM)	12.69	7.98*
	(2.59)	(1.33)
CD (% of AUM)	18.28	20.79
	(3.03)	(2.23)
Treasury Debt (% of AUM)	14.09	14.31
	(2.62)	(2.88)
Agency Debt (% of AUM)	15.69	14.99
	(3.46)	(2.95)
Financial CP (% of AUM)	7.45	10.78*
	(1.41)	(1.13)
Asset-Backed CP (% of AUM)	2.40	6.84***
	(0.56)	(0.99)

Notes: This table reports summary statistics as of June 28, 2013 (the last quarter-end before the ONRRP began) for treated (ever constrained) and control (never constrained) MMFs in our sample. All dealer-related variables (number of dealers, % foreign, CDS spread, and HHI) are based on a sample of only MMFs that have non-zero private repo volume (90 MMFs rather than the full 107). Rates are calculated on a fund complex level, while all other variables are at the individual MMF level. Statistical significance of change in averages: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.

Table 2
Money Market Mutual Investment Shares

Asset Class	2013 Q3	2014 Q3
Fed ONRRP	3.32	13.67***
	(0.35)	(1.34)
Treasury Repo	9.43	5.26**
	(1.58)	(0.95)
Agency Repo	8.54	5.30**
	(1.16)	(0.81)
CD	20.51	21.99
	(1.87)	(1.96)
Treasury Debt	14.06	9.60*
	(2.00)	(1.83)
Agency Debt	14.81	16.38
	(2.21)	(2.48)
Financial CP	9.05	8.62
	(0.94)	(0.83)
Asset-Backed CP	4.70	4.78
	(0.64)	(0.67)
N	107	107

Notes: This table reports average asset holdings as a share of total assets under management for the pre-treatment quarter (2013 Q3) and the final increase in the counterparty cap (2014 Q3). Statistical significance of change in mean asset share: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.

Table 3
Regression Results: MMF Asset Substitution

Dependent Variable	Treatment Group	(1)	(2)	(3)	(4)
Fed ONRRP	Unbound_{it}	8.77***	9.73***	7.74***	8.47***
		(1.76)	(1.81)	(2.22)	(2.11)
	Bound_{it}	6.49***	8.02***	6.12***	7.82***
		(1.68)	(1.73)	(1.81)	(1.88)
Treasury Repo	Unbound_{it}	-3.90***	-4.90***	-5.69***	-6.19***
		(1.43)	(1.63)	(1.24)	(1.45)
	Bound_{it}	-3.60***	-5.19***	-4.63***	-5.79***
		(1.14)	(1.41)	(1.11)	(1.18)
Agency Repo	Unbound_{it}	-2.76**	-2.92**	-2.70**	-2.80**
		(1.28)	(1.36)	(1.33)	(1.38)
	Bound_{it}	-0.22	-0.47	-0.40	-0.63
		(1.82)	(1.98)	(1.63)	(1.70)
CD	Unbound_{it}	-2.23***	-2.74***	-0.82	-1.18
		(0.70)	(0.57)	(1.04)	(1.01)
	Bound_{it}	-2.29***	-3.10***	-1.49	-2.34*
		(0.82)	(0.87)	(1.14)	(1.39)
Treasury Debt	Unbound_{it}	0.02	-0.13	0.05	0.11
		(1.45)	(1.49)	(1.75)	(1.84)
	Bound_{it}	1.60	1.36	1.39	1.53
		(1.32)	(1.33)	(1.44)	(1.53)
Agency Debt	Unbound_{it}	1.28	1.78*	2.37*	2.36*
		(1.06)	(1.03)	(1.14)	(1.19)
	Bound_{it}	0.45	1.24	1.14	1.12
		(0.74)	(1.07)	(1.22)	(1.35)
Financial CP	Unbound_{it}	0.68	0.64	0.27	0.17
		(0.80)	(0.90)	(0.78)	(0.78)
	Bound_{it}	-0.14	-0.21	-0.36	-0.59
		(0.69)	(0.89)	(0.89)	(0.87)
Asset-Backed CP	Unbound_{it}	0.17	0.20	0.36	0.40
		(0.48)	(0.45)	(0.49)	(0.47)
	Bound_{it}	0.37	0.42	0.46	0.55
		(0.41)	(0.41)	(0.44)	(0.42)
Initial AUM*Post		No	Yes	No	Yes
Fund trends		No	No	Yes	Yes
N		1,177	1,177	1,177	1,177

Notes: This table reports DD estimates of the effect of an increase in the ONRRP counterparty cap on MMF asset allocation. $Unbound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap, but, as a result of subsequent cap increases, no longer find the counterparty cap binding. Similarly, $Bound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap and continue to face a binding cap despite subsequent increases. Column 1 contains no other controls, while columns 2 and 4 include AUM as a control for fund size. Columns 3 and 4 control for fund-specific trends. All specifications include fund and quarter fixed effects, with standard errors clustered at the fund complex level. Statistical significance: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.

Table 4
Regression Results: Placebo Tests of MMF Asset Substitution

Panel A: Placebo Treatment within Sample					
Dependent Variable	Treatment Group	(1)	(2)	(3)	(4)
Fed ONRRP	Unbound_{it}	8.13***	9.16***	7.89***	8.55***
		(1.78)	(1.69)	(2.22)	(2.19)
	Bound_{it}	6.31***	7.85***	6.31***	7.91***
		(1.61)	(1.60)	(2.05)	(2.19)
	Placebo_{it}	1.02	0.90	0.65	0.37
		(1.76)	(1.76)	(2.22)	(2.20)
Treasury Repo	Unbound_{it}	-4.35***	-5.45***	-5.57***	-6.04***
		(1.27)	(1.51)	(1.29)	(1.47)
	Bound_{it}	-3.73***	-5.35***	-4.49***	-5.61***
		(1.10)	(1.38)	(1.21)	(1.25)
	Placebo_{it}	0.74	0.86	0.50	0.69
		(1.05)	(1.04)	(1.37)	(1.38)
Agency Repo	Unbound_{it}	-2.50*	-2.67**	-2.93**	-3.01**
		(1.25)	(1.33)	(1.34)	(1.39)
	Bound_{it}	-0.14	-0.40	-0.69	-0.88
		(1.80)	(1.96)	(1.61)	(1.68)
	Placebo_{it}	-0.41	-0.39	-1.01	-0.98
		(0.55)	(0.55)	(0.74)	(0.73)
CD	Unbound_{it}	-1.74**	-2.29***	-0.77	-1.10
		(0.69)	(0.56)	(1.05)	(1.00)
	Bound_{it}	-2.15**	-2.96***	-1.43	-2.24*
		(0.87)	(0.92)	(1.06)	(1.31)
	Placebo_{it}	-0.77	-0.71	0.22	0.36
		(0.61)	(0.60)	(0.55)	(0.56)
Panel B: Placebo Treatment in Pre-ONRRP Sample					
Dependent Variable	Treatment Group	(1)	(2)	(3)	(4)
Treasury Repo	Placebo_{it}	0.15	-0.06	1.74	1.56
		(1.61)	(1.84)	(1.60)	(1.65)
Agency Repo	Placebo_{it}	0.10	-0.13	1.90	1.67
		(0.82)	(0.95)	(1.72)	(1.85)
CD	Placebo_{it}	0.12	0.83	1.09	2.40
		(1.41)	(1.36)	(1.68)	(1.72)
Initial AUM*Post		No	Yes	No	Yes
Fund trends		No	No	Yes	Yes

Notes: This table reports DD estimates of the effect of an increase in the ONRRP counterparty cap on MMF asset allocation, as described in Table 3. In the table above, Panel A uses the same sample as Table 3, but includes a placebo treatment variable, Placebo_{it}, which takes a value of one for treated funds beginning in the period after these funds become unconstrained. Panel B uses a sample of the same funds for the 11 quarters *prior* to the introduction of the ONRRP. In Panel B, Placebo_{it} takes a value of one for treated funds beginning in December 2011, five quarters after the beginning of the sample. All specifications include fund and quarter fixed effects, with standard errors clustered at the fund complex level. Statistical significance: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.

Table 5
Regression Results: MMF Asset Substitution at the Relationship Level

Panel A: Treasury Repo

	(1)	(2)	(3)	(4)
Unbound_{it}	-0.37***	-0.38***	-0.36**	-0.34**
	(0.12)	(0.14)	(0.13)	(0.14)
Bound_{it}	-0.28***	-0.28**	-0.29***	-0.28***
	(0.10)	(0.10)	(0.10)	(0.09)
Dealer*Time FEs	N	Y	N	Y
Dealer-Fund trends	N	N	Y	Y
Observations	9,075	9,075	9,075	9,075
Adj. R^2	0.45	0.48	0.61	0.62

Panel B: Agency Repo

	(1)	(2)	(3)	(4)
Unbound_{it}	-0.26**	-0.29**	-0.34**	-0.35***
	(0.10)	(0.12)	(0.13)	(0.13)
Bound_{it}	0.02	0.01	-0.04	-0.05
	(0.16)	(0.18)	(0.14)	(0.15)
Dealer*Time FEs	N	Y	N	Y
Dealer-Fund trends	N	N	Y	Y
Observations	9,955	9,955	9,955	9,955
Adj. R^2	0.51	0.53	0.68	0.68

Notes: This table reports DD estimates of the effect of an increase in the ONRRP counterparty cap on MMF repo trades with dealers. $Unbound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap, but, as a result of subsequent cap increases, no longer find the counterparty cap binding. Similarly, $Bound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap and continue to face a binding cap despite subsequent increases. Column 1 contains no other controls, while columns 2 and 4 include dealer*time fixed effects. Columns 3 and 4 control for trends specific to each unique dealer-fund pair. All specifications include relationship and quarter fixed effects, with standard errors clustered at the fund complex level. Statistical significance: $^{***}\ p \leq 0.01,^{**}\ p \leq 0.05,^{*}\ p \leq 0.10$.

Table 6
Regression Results: MMF/Dealer Relationships

Panel A: No Fund Trends

	Number of Dealers		Weighted CDS Spread		HHI		Share Largest Dealer	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Unbound_{it}	0.01	-0.85	0.09	0.02	-0.04	-0.02	-0.02	-0.01
	(0.39)	(0.72)	(0.07)	(0.06)	(0.04)	(0.05)	(0.04)	(0.04)
Bound_{it}	0.47	0.60	0.12	-0.001	-0.08	-0.12**	-0.06	-0.11*
	(0.48)	(0.73)	(0.07)	(0.05)	(0.09)	(0.06)	(0.08)	(0.06)
N	803	839	674	779	803	839	803	839
Adj. R^2	0.94	0.94	0.90	0.94	0.88	0.87	0.92	0.91

Panel B: With Fund Trends

	Number of Dealers		Weighted CDS Spread		HHI		Share Largest Dealer	
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Unbound_{it}	0.29	-0.49	0.05	0.03	-0.12	-0.08	-0.08	-0.06
	(0.56)	(0.62)	(0.09)	(0.10)	(0.07)	(0.06)	(0.06)	(0.05)
Bound_{it}	0.58	0.70	0.09	-0.002	-0.10	-0.15**	-0.08	-0.13**
	(0.52)	(0.81)	(0.07)	(0.06)	(0.10)	(0.07)	(0.09)	(0.06)
N	803	839	674	779	803	839	803	839
Adj. R^2	0.96	0.96	0.92	0.96	0.91	0.90	0.94	0.93

Notes: This table reports DD estimates of the effect of an increase in the ONRRP counterparty cap on MMF relationships in the repo market. $Unbound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap, but, as a result of subsequent cap increases, no longer find the counterparty cap binding. Similarly, $Bound_{it}$ takes a value of one for funds that previously experienced a binding counterparty cap and continue to face a binding cap despite subsequent increases. Dependent variables include the number of dealers per fund, the weighted CDS spread of dealers that trade with each fund, and the Herfindahl (HHI) index for each fund (calculated using volume transacted with each dealer). For each dependent variable, column 1 includes Treasury collateral repo transactions and column 2 includes Agency collateral repo only. Panel A excludes fund-level trends from the specification, whereas the specifications in Panel B include fund trends. All specifications include fund and quarter fixed effects, with standard errors clustered at the fund complex level. Statistical significance: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.

Table 7
Regression Results: Repo Rates

Panel A: 1st Cap Increase

	Weighted Average Rate			Memo: 25th Percentile Rate			Memo: 75th Percentile Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Bound_{t-1}$	0.26**	0.23***	0.23**	0.32***	0.44**	0.47**	0.26**	0.21	0.20
	(0.10)	(0.08)	(0.09)	(0.10)	(0.16)	(0.20)	(0.12)	(0.13)	(0.15)
N	177	533	444	177	533	444	177	533	444
Adj. R^2	0.99	0.98	0.98	0.99	0.88	0.86	0.99	0.97	0.97

Panel B: 1st and 2nd Cap Increase

	Weighted Average Rate			Memo: 25th Percentile Rate			Memo: 75th Percentile Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Bound_{t-1}$	0.26***	0.47**	0.53**	0.30***	0.62*	0.70*	0.25***	0.51**	0.57**
	(0.07)	(0.19)	(0.23)	(0.09)	(0.31)	(0.38)	(0.07)	(0.22)	(0.27)
N	345	1,043	869	345	1,043	869	345	1,043	869
Adj. R^2	0.98	0.84	0.82	0.98	0.79	0.76	0.98	0.80	0.77

Panel C: 1st, 2nd, and 3rd Cap Increase

	Weighted Average Rate			Memo: 25th Percentile Rate			Memo: 75th Percentile Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Bound_{t-1}$	0.13*	0.35***	0.39***	0.14*	0.43***	0.49***	0.11*	0.35***	0.40**
	(0.06)	(0.09)	(0.11)	(0.07)	(0.14)	(0.17)	(0.06)	(0.12)	(0.15)
N	497	1,510	1,258	497	1,510	1,258	497	1,510	1,258
Adj. R^2	0.98	0.86	0.84	0.98	0.82	0.79	0.98	0.83	0.80

Panel D: 1st, 2nd, 3rd, and 4th Cap Increase

	Weighted Average Rate			Memo: 25th Percentile Rate			Memo: 75th Percentile Rate		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Bound_{t-1}$	0.18*	0.31*	0.36*	0.23*	0.40*	0.46	0.20	0.34	0.39
	(0.10)	(0.17)	(0.20)	(0.12)	(0.23)	(0.27)	(0.21)	(0.13)	(0.25)
N	643	1,943	1,618	643	1,943	1,618	643	1,943	1,618
Adj. R^2	0.90	0.81	0.78	0.89	0.77	0.74	0.89	0.77	0.73

Notes: This table reports DD estimates of the effect of an increase in the ONRRP counterparty cap on MMF repo rates. $Bound_{t-1}$ takes a value of one for fund complexes that had at least one fund facing a binding cap on the day before an increase. Panel A includes data from the first cap increase—September 27, 2013—only. Panels B through D add data from days around the three subsequent cap increases: December 23, 2013, January 30, 2014, and March 5, 2014. Column 1 includes a two-day sample window spanning the day before and day of a cap increase. Column 2 uses a six day sample window including the five days prior to the cap increase. Column 3 uses the same sample as column 2, but drops the day before the cap change (the announcement day). Results are reported for fund complexes' volume-weighted average rate and the volume-weighted 25th and 75th percentile rates, as indicated. All specifications include fund and day fixed effects, with standard errors clustered at the fund complex level. Statistical significance: *** $p \leq 0.01$,** $p \leq 0.05$,* $p \leq 0.10$.