Quid Pro Quo: Liquidity Insurance in US Tri-party Repos

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This paper provides a comprehensive examination of how over-the-counter trading relationships significantly affect short-term interest rate dynamics in the US tri-party repo market. We test the prediction that over-the-counter search friction incentivize dealers to pay a liquidity insurance premium to their relationship money market funds (MMFs). In case of a market wide liquidity shortage, dealers can still obtain funds from their relationship funds at favorable terms, thus effectively smoothing out the negative shock. Specifically, we use the Oct.2016 MMF Reform as a quasi-natural experiment to find relationship funds provide short-term financing at favorable rates and haircuts to linked dealers. We also find the trading relationships are stable over time. In case of a forced drop of relationship funds during the liquidation of Charles Schwab Money Market Sweep Funds, dealers had to bear a higher cost when searching for new partners. These findings imply that relationship significantly impact short-term rates, and relationship bundling might exacerbate the next crisis if MMFs experience fund runs.

Keywords: over-the-counter, trading network, Money Market Funds reform, repo pricing

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I. Introduction

During the financial crisis of 2007-2009, it became apparent that the U.S. tri-party repurchase agreement (Tri-party Repo) market, used by dealers every day to finance their asset purchase, has a significant weakness: when trust between trading counterparties unraveled, regardless of institution's financial health, trading counterparties disappeared instantly. Financing costs soon rocketed sky-high and defaults followed, causing a chain-reaction. Indeed, in September 2008, when Reserve Primary Fund adjusted its NAV below $1, it quickly spread to other prime and muni MMFs, triggering investors' redemptions of more than $300 billion within a few days after the default of its most important linked dealer--Lehman Brothers. This run caused a severe shortage of short-term credit to the banking sector (Kacperczyk and Schnabl, 2013). The interaction between risk-taking incentives and exposure to runs made MMFs reform a necessity in the post-crisis regulatory environment, so SEC imposed a new regulation on prime money markets funds to be complied on Oct.2016. Under the new rules, institutional prime MMFs are required to float their NAVs, thus breaking their perceived "safe assets" status.

However, the effectiveness of the MMF reform is yet to be validated. The opaqueness of the Tri-party repo market comes with the nature that it is over-the-counter, and the fact that traders rely on phone calls to borrow/lend trillions of dollars per day accentuates the underlying risk in this market. Worse still, dealers use this market to borrow overnight funding, then purchase long-term assets, while rolling over this short-term debt day-by-day. The most recent repo market turmoil of Sept.2019 is a great manifestation. In Figure 1, US short-term rate market experience an unforeseen 300% increase of secured overnight borrowing rate (SOFR). The objective of designing SOFR by the Federal Reserve is hoping that one day, it will replace the rigged LIBOR rates, and serve as a guidance to US short-term funding market. But such an expected spike of short-term rates clearly invalidates Fed's objectives. As a result, Fed had to inject liquidity facility (again) to bring down the borrowing rates. Anecdotal evidence on Wall Street suggest that the spike is caused by a holiday

of Japanese banks, where a lot of US dealers obtain their repo funding from. On Sept.17th, there's no Japanese trader on their desks, so US dealers had to borrow money from their less frequent counterparties.

One lesson we learned from the crisis is that trading counterparties need stable relationships to mitigate the effect of credit events and liquidity events, especially in repo market, an over-the-counter market where most trades are completed over the phone. In such an OTC market, buyers and sellers search and meet to bargain over the terms of trades. A large fraction of transactions in the economy are negotiated and settled in OTC markets. Mortgage-backed securities, derivatives, corporate bonds, and syndicated bank loans are only a few examples of large OTC markets. compared to centralized platforms, such as exchanges or auctions.

Despite OTC trading relation's importance to the market, very few empirical researches have been done on how the relationship is formed and applied to explain the asset price dynamics, mainly due to the lack of available transactions data. In this paper we study a specific OTC market, the tri-party repurchase agreement market in the US, for which we can obtain detailed information on individual transactions from N-MFP filings in EDGAR database, and match it with N-SAR filings, also from EDGAR database, that includes the rankings of trading counterparties based on the trading volume of all asset classes The Oct.2016 compliance date of the Money Market Reform provides us with a clean identification to study MMFs' interaction with dealers in the tri-party repo market. Repurchase agreements (repos) are considered to be the largest and the most important short-term financing channel for a variety of financial institutions (Hu, et al, 2019). We analyze how trading relationships in this market are formed and how they affect pricing and the provision of liquidity across MMFs.

Several papers have recently shown that search cost leads to relationship formation in over-the-counter (OTC) market. Theoretically, Duffie (2012) shows that search frictions affect investor behavior and trade outcomes in OTC markets. This friction is driven by either search costs or

asymmetric information. Empirically, recent studies document an important role of trading relationships in various OTC markets, including, for example, the interbank markets where banks trade unsecured claims on their excess reserves (Ashcraft and Duffie, 2007; Afonso et al., 2014), money market fund lending (Chernenko and Sunderam, 2014; Han and Nikolaou, 2016), and dealer-intermediated fixed-income trading (Li and Schurhoff, 2019; Di Maggio et al., 2015).

In this paper, we use the Oct.2016 SEC reform of the money market funds (MMF) as a quasi-natural experiment to show that dealers are willing to pay a premium during normal times, so that they can get preferential treatment when a liquidity shock hits the market. The SEC MMF reform changed the market liquidity and imposed tighter constraints on institutional prime MMFs. One restriction is institutional prime MMFs can no longer operate on a stable $1 NAV. Instead, the NAV should be floated, which caused significant outflows from institutional Prime MMFs. Many companies have done the product change, switching Prime MMF offerings into Government MMFs. We leverage such a differential treatment to institutional prime MMFs, and use Difference-in-Difference identification to estimate the liquidity insurance premium paid by an average dealer, and the average payoff of the dealer after a liquidity shock hits the market. We highlight how relationship significantly affects the short-term rate dynamics: while the average borrowing premium a dealer pays to be trading partner of a Prime MMF is ~8 basis points, in times of liquidity shock, Prime MMFs return the favor with a discount of ~10 basis points, compared to similar repo trades that use the same kind of collateral, with fund characteristics and dealer characteristics controlled. The result is surprising, considering treated MMFs themselves are facing tighter liquidity constraints.

The estimated value of trading relationship has important macroeconomic and financial stability implications. First, we find that trade counterparties, particularly larger ones, form stable relationships with a broad set of counterparties and concentrate their transactions on several largest counterparties. Regarding the strength of trading relationships, we directly pull the ranking of 10 largest trading counterparties of an MMF from N-SAR forms. We also use the concentration of the

dealer's total borrowing from the MMF and construct dependence measure of both the MMF and the dealer. The advantage of our measure is that we rule out the possibility that the stronger relationship is due to more attractive prices. Our measure also allows us to explore a wider scope of trading relations covering other financial instruments, including equity and bonds, testing if there exist economies of scale in relationship formation. MMFs invest not only in repos, but also in other instruments, such as commercial paper (CP) and certificates of deposits (CDs), that dealers intermediate or issue. As such, MMFs might offer discount to dealers in the tri-party repo market if it helps them achieve their overall strategic asset allocation across markets and overall profitability. Our results support this prediction, as we find that MMFs tend to form stronger relations in repo market with dealers who have largest transaction volume with the MMF. For the benefit of economy of scale, MMFs will give discount to those dealers that keep strong trading relations.

Our finding that dealers are willing to pay a liquidity insurance premium in normal times, in exchange for preferential treatment in the tri-party repo market during market stress may help reconcile the seemingly contradictory results in previous OTC trading relationship studies. Specifically, on the one hand, Ashcraft and Duffie (2007) find the stronger the trading relations, the higher the borrowing rate will be in the interbank offering market, implying banks are willing to pay premiums to reduce search cost. On the other hand, Afonso et al. (2014) find that stronger trading relations lead to lower borrowing rate in the interbank offering market, implying that banks mutually insure each other to defend against liquidity shock. We rule out the mutual insurance case by using the tri-party repo market data instead of the inter-bank offering data, because in tri-party repo market, borrowing-lending relationship is unidirectional: MMFs are always providing liquidity, and dealers are always demanding liquidity. Therefore, relationship plays a dynamic role between two negotiating parties, and it's effect on the short-term interest rate will be solely determined by the strength of relationship, with all other fund/dealer characteristics controlled

Our result is consistent with Bolton, et al (2016) that banks have incentives to smooth out the interest charged on loans in the presence of an aggregate economy-wide shock, as MMFs here, which is a shadow bank, will get higher expected profits due to the liquidity insurance premiums consistently paid from the dealer. Dealers are also incentivized to purchase this form of liquidity insurance, as the insurance will significantly smooth out liquidity shocks.

We also extend the existing over-the-counter research literature in a new direction, connecting the internal dynamics of trading partnership to the dynamics of short-term interest rates. We create an innovative data set by combining MMF repo transaction data in N-MFP forms, with a broader scope of trading relations in N-SAR forms, to examine trading relationships both over time and across lender-borrower pairs.

The rest of the paper is organized as follows. Section 2 presents a description of the money market reform and discusses our data. Section 3 presents our empirical results. Section 4 concludes.

II. Data and Methodology

A. Money Market Fund Reform

In July of 2014, the SEC approved a new reform on MMFs. The main pillar of these rules is that from October 2016, institutional prime & muni MMFs must sell and redeem shares based on the current market-based value of the securities in their underlying portfolios. Namely, they have to move away from a stable NAV to a floating NAV. The purpose of this regulatory change is to mitigate the risk of runs. In addition, all prime & muni MMFs will have discretion to impose “gates” on redemptions or charge redemption fees of up to 2% in times of stress.

The new regulation came into effect in October 2016, and the most affected fund type is institutional prime money market funds, other types of funds are left unchanged. In this paper, we exploit this differential treatment. We do so by studying tri-party repo data from MMF regulatory

filings with the SEC (form N-MFP) both before and after reform. We find that although dealers who have a strong trading relationship with MMFs on average pay a premium to sustain this relationship, in times of market liquidity shock after the new regulation is in place (Oct.2016), those dealers actually get rewarded for being a trading partner, namely, they get a discount in borrowing rate. The tri-party repos have mostly traded between MMFs fund families and dealers, so utilizing this new reform will enable us to look into the two major players' interaction in this market when there's an exogenous shock to the liquidity, while holding other factors fixed. This difference in difference design will provide a clean identification to the hypotheses we want to test.

B. N-MFP forms and N-SAR forms

The Form N-MFP is a publicly available regulatory filing that every MMF is required to submit to the SEC each month, and N-SAR is another filing that every MMF is required to submit to the SEC every 6 months. Each N-MFP filing contains information on a fund's balance sheet, share classes, security-level portfolio holdings, performance, and investor flows. Each N-SAR form includes a list of survey questions regarding trading volume and trading partners. Funds reports all of form N-MFP information submit their filings to the SEC within the first five business days of the next month. The SEC makes all N-MFP submissions and N-SAR submissions publicly available. The N-MFP was created in May 2010 along with a set of MMF reforms adopted in the immediate aftermath of the financial crisis. The first N-MFP filings were submitted in December 2010 and have continued every month since. N-SAR filings, on the other hand, have already been in place before the crisis. We download, parse, and clean information from the form N-MFP to construct our monthly panel dataset of MMFs' repo transaction with dealers. We then do the same from the form N-SAR to get the largest 10 dealers that trade with the MMFs, reported semi-annually. A fund's N-MFP filing specifies whether the fund is a feeder or a master fund, whether it is liquidating or merging with another fund, and whether it is a prime fund, a municipal fund, an agency fund, or a

treasury fund. The filing reports the fund's month-end dollar weighted average portfolio maturity, total net assets, and the annualized gross yield for the last seven days of the month. The fund also reports its fixed NAV, at which shares are redeemed and subscribed. Most importantly, form N-MFP has a month-end snapshot of the MMFs' portfolio holdings, including detailed transaction of tri-party repo between an MMF and counterparties, mainly security dealers. Form N-SAR has an entry numbered 22 that includes MMFs' total portfolio transactions with counterparties. The list has 10 entities acting as principals with whom MMF did the largest amount of portfolio transactions (include all short-term obligations, and U.S. Gov't & tax-free securities) in both the secondary market & in underwritten offerings in order of size based upon total value of principal transactions during the semi-annual reporting period.

One fund can have multiple share classes, that is, types of shares that differ in terms of fees, minimum investment, and other characteristics. For each of its share classes, the fund reports the net assets, the aggregate monthly redemptions and subscriptions by shareholders, and the annualized net yield for the last seven days of the month. But in N-MFP filings, we find that repo transactions are completed at the fund family level, which is not surprising, because parent fund manages the liquidity of funds distributed to each child fund. Operating liquidity on the fund family level also has the advantage of a money pool that mitigates the effect of redemption to certain share classes. Therefore, we identify 98 fund families and 31,019 repo transactions at the fund family level from 2013 to 2019 from form N-MFP. We then match the 10 largest dealers reported in N-SAR filing that trade with a given fund family, to investigate for a given repo transaction, whether trading terms will change significantly if the counterparty is in the top 10 trading partner list.

C. Hypotheses Development

Whether trading relationship incurs premium or discount still remains unresolved in the literature. On one hand, trading counterparty might pay a premium to keep a trading relationship, because finding another stable relationship is costly, according to Duffie, et al (2005). On the other hand, trading relationship might also bring discount, since trading counterparties might want to mutually insure in preparation for the next credit events or liquidity events, as shown in Afonso, et al (2014), Han & Nikolaou (2016).

Previous research focus on symmetric market such as inter-bank offering market. Problem with this approach is that it's a competitive market and we have no ways to identify whether a trade's premium or discount is due to relationship or due to competitive bidding. We directly pin down the relationship using N-SAR filing's reported list of 10 largest trading counterparties. The N-SAR filing has an entry #22: List the 10 entities acting as principals with whom Registrant did the largest amount of portfolio transactions (include all short-term obligations, and U.S. Gov't & tax-free securities) in both the secondary market & in underwritten offerings set forth in order of size based upon total value of principal transactions during the current reporting period. We use this list of trading partners for each MMF to study an asymmetric market, where MMFs are always providing liquidity, and dealers are always demanding liquidity, to avoid the endogeneity problem that relationship's effect on trading terms is determined by trading activity. It also rules out the mutual insurance argument in Afonso, et.al (2014), and service bundling commission argument in Goldstein, et al. (2009).

The MMF industry is divided in three main sectors based on funds' portfolio composition: 1) prime MMFs mainly invest in private unsecured and secured debt in addition to Treasuries and Agency debt; 2) muni MMFs mainly invest in municipal and local authorities debt; 3) government MMFs mainly invest in Treasuries and Agency debt and can only lend to the private sector through repurchase agreements (repos) collateralized by Treasuries or Agency debt. Government MMFs can

be further divided in two subgroups: Treasury MMFs, which can only invest in Treasuries and repos collateralized by Treasuries; and Agency MMFs, which can also invest in Agency debt and repos collateralized by Agency debt. Since each repo type corresponds only certain type of MMFs, using we expect the repo transaction data will provide a clean view of relationship between MMFs and their corresponding trading partners.

D. The Model

We propose the model as the following:

$$Y_{ijt} = c_{ij} + \eta_{it} + \mu_{jt} + \beta_1 \times Relation_{ij} + \beta_2 \times Reform_t + \beta_3 \times Relation_{ij} \times Reform_t + \beta_4 \times Control_{ijt} + \varepsilon_{ijt}$$

Y_{ijt}: *repo rate, or repo haircut.* To test whether trading partnership has premium or discount in the tri-party repo market, we use the repo rate (repo yield) as our dependent variable. We also investigate the effect of trading relationship on the trading principal and trading haircut, to see if MMFs will provide special trading terms to their trading partners, after tenor and collateral of the contract have been controlled.

$Relation_{ij}$: *friend or rank_high*. We create *friend* as a dummy variable that equals to 1 if the dealer in a given repo transaction is in the top 3/5/10 trading partner list of the MMF. Since the top 10 list rank the trading volume from large to small, we use the numbered ranking (10 to largest, 1 to smallest, 0 to those dealers not in the list) as *rank_high* to see if higher-up ranking in the top 10 list leads to more pronounced effect compared to the effect of just being in the top 10 list (*friend*). Other alternative definitions include *Volume1m, Volume3m, Count1m, Count3m.* For example, *Volume1m* equals 1, if among all the trading partners of a given fund in the last month(*1m*), a dealer ranks in the top 1/3 in terms of total repo trading volume with the fund. Whereas *Count3m* equals 1, if among

all the trading partners of a given fund for the past 3 months($3m$), a dealer ranks in the top 1/3 in terms of total repo trading frequencies with the fund.

$Reform_t$: After Oct.2016, the new money market reform became effective. Other researches such as Cipriani and La Spada (2018) use other MMF Reform cutoff, including July.2014 and Nov.2015. But we found in N-MFP form has a self-reported tag that shows whether a prime fund is exempt from the new regulation, indicating the MMF is a retail prime MMF. The exempt tag switch only happened on Nov.2016. Thus, prime MMFs do not comply to the new regulation in the transition period (2014-2016). Instead, MMFs only comply after the new regulation came into effect. This is the exact reason why Cipriani and La Spada (2018) don't find significant result for cutoffs other than Oct.2016.

$Prime_{ijt}$: $Prime$ equals 1 if a MMF is an institutional prime money market fund. The data is taken from CRSP Mutual Fund header information data.

$Control_{ijt}$: we control for tenor and collateral liquidity of a given repo contract, to hold fixed the risk factors that can explain the repo rate. We also control for fund size and dealer size, to account for the fact that larger trading partners will have stronger bargaining power.

c_{ijt}: Repo-type fixed effect to control for the unobservable that is respective to each type of repos (Treasury Repo, Agency Debt Repo, Corporate Bond Repo, Equity Repo).

η_{it}: Fund family fixed effect for the unobservable that is respective to each of the 290 unique portfolios.

μ_{jt}: Time fixed effect to eliminate confounding factors over time periods.

III. Result

We first look at summary statistics of our sample, which includes 1 year before the Oct.2016 MMF reform, and 1 year after the Oct.2016 MMF reform. In Table 1, we can see that even though both the relationship funds and non-relationship funds have increased repo rates significantly since the Oct.2016 MMF Reform, the relationship funds only raise the repo rates by 45 basis points. Whereas non-relationship funds raise the repo rates by 55 basis points. We can also see that the relationship funds charge a higher repo rate of 42 basis points, while non-relationship funds charge only 38 basis points. Table 1 implies that relationship linked dealers are paying a premium before the liquidity shock hits the market, but after the liquidity shock, the premium dealers paid is effectively an insurance premium, as funds provided liquidity to the linked dealers at a more favorable condition, compared to non-relationship trading partners.

[Table 1]

We then investigate whether repo rate is affected by the relationship dummy over the whole sample period After controlling for fund family fixed effect, time fixed effect and repo type fixed effect, relationship fund will on average charge 1bp higher to linked dealers over the whole sample period. 1 day increase in the contract tenor will increase the repo rate for 0.1 basis points, consistent with the term premium of repo contract, though economically negligible. Also, less liquid collateral will be harder to liquidate in case of default, so MMFs will charge a higher repo rate (16 basis point more) for dealers that use illiquid collaterals, as shown in Table 2.

We then investigate whether the amount borrowed will be larger if the dealer ranks high in the top 10 dealer list of the MMF. After controlling for fund family fixed effect and time fixed effect, 1 unit increase in dealers' rank will increase the amount that can be borrowed. Using illiquid collateral

will decrease the amount that can be borrowed. However, both effects are economically insignificant despite being statistically significant, so we don't report here.

From Table 2 we can argue that the rankings' effect is not from MMFs demanding a risk compensation for dealers who borrow too much from them. Because being higher up in the rank and using illiquid collaterals only slightly changes the amount borrowed to the extent that we can ignore the effect.

[Table 2]

Haircut is commonly used in repo transaction, as MMFs normally receive collaterals that have a larger market value than the principal value they actually lend to the dealers. This is to ensure that MMFs can liquidate the collateral in the event of default and get as much money back as possible.

In Appendix A1 we find that higher up in the dealers' rank does affect haircut, after controlling for all other factors. We find similar result to Table 2. However, the haircut is already in percentage terms, so being a significant trading partner will increase the haircut by ~0.12%, which is negligible. Nagel et al(2014) find that even during the 2008 financial crisis, the haircut is quite stable around 2-3%, and here we found similar results corroborating their findings.

However, finding that relationship trading partners pays a premium can be explained in many possible ways. One is that relationship funds, based on past accumulative transactions, already has too much skin in the game. So to compensate the default risk, the relationship fund will charge a higher borrowing rate. On the other hand, this premium might just be due to the different bargaining power of two trading counterparties. To investigate where the effect might come from, we run regressions utilizing the dealer dependence measure and fund dependence measure defined in Han & Nikolaou (2016), and the result is shown in Table 3.

[Table 3]

In Table 3, we can see that the "Skin in the Game" can be a candidate explanation, that when dealers take up a larger percentage of a fund's lending, both frequency wise and volume wise, fund will charge a higher interest rate. However, this explanation will simply contradict the summary statistics that for relationship funds, those funds even increased lending amount while charging a smaller markup to their linked dealers. If "Skin in the Game" hypothesis holds, then funds are expected to lend less or charge a higher interest rate when liquidity shock hits the market, but neither happened in our data.

Next we use a difference-in-difference design to study when an exogenous liquidity shock hits the US Tri-party Repo Market, will relationship MMF charge a higher or lower price to the dealer, holding other factors constant.

[Table 4]

Table 4-6 shows the result using several different relationship variables: We find that in each table, *PrimeMMF*Post-Reform* has significantly positive coefficients, which is consistent with the fact that Prime MMFs and their linked dealers were hit the hardest in the aftermath of MMF reform. We find the exact same result when we change *Relation* dummies from NSAR dealer ranking based ones *NSAR_TOP3, NSAR_TOP5, NSAR_TOP10*, to NMFP universe trading record ones *Volume1m, Volume3m, Count1m, Count3m.*

But once we interact *Relation* with *PrimeMMF*Post-Reform*, the effect of *PrimeMMF*Post-Reform*Relation* is actually negative. This is consistent with the summary statistics in Table 1: even the MMF reform hits the market and significantly raise the average interest rate asked by

PrimeMMFs, if the dealer is among one of the closely linked dealers, they still get favorable trading terms.

[Table 5-6]

To summarize, a dealer will have to pay an average premium of 8 basis points being in the top linked-dealer list., 1 year before the MMF reform. However, those affected Prime MMFs will return the favor with ~10 basis point less markup to the linked dealers, thus effectively serving the role of liquidity insurer.

The benefit is obvious: dealers can purchase an insurance that facilitates their daily roll-over of short-term debt, that is mostly leveraged and invested in long-term securities such as corporate bonds. And the consequence is that over time, MMFs and dealers build stable relationships that is shown in Figure 2.

[Figure 2]

Figure 2 graphs the total number of repo transactions (frequency) between each matched MMF and linked dealers. Blue square means the matched MMF and linked dealer has over 1000 repo transaction in the dataset. Light green square means the corresponding MMF and dealer has almost zero repo transaction. The Y axis is the coded MMF name, and the X axis are the major dealers in this market.

For the several deep blue squares in Figure 2, the relationship MMFs are Fidelity Government Fund Family and Fidelity Prime Fund Family, and the linked dealers are Bank BNP Paribas, MUFJ, and Royal Bank of Canada. As in Hu, et al(2019), they also find that Fidelity Fund Family is the "systematically important player" in the US Tri-party Repo market. Figure 2 also shows that the trading relationships are stable over time, with a lot of pairs in light blue (strong trading relations),

and a sparse matrix mostly consist of light green, which means the matched pairs have little to zero trading relationship.

Our result, unlike previous researches in the literature, captures borrowing rate premium and discount under the same setting. The surprising result that affected MMFs even lend more to linked dealers, at favorable terms, can be explained by MMFs' needs to place investors' cash in a predictable and smooth way when there's a market wide liquidity shock. This result cannot be explained by the commission bundling (Goldstein, et al, 2009) or mutual insurance (Afonso, et al, 2014) because the dealer is not providing service to the MMF in the repo transaction, and the asymmetric nature of the tri-party repo markets means there's no mutual insurance in this market. In this case, the relationship premium can be explained by the search cost as in Duffie (2005), and the surprising relationship discount can only be explained by MMFs reliance on their trading relationship with dealers. Whether MMFs are rewarding relationships or smoothing their investment on dealers need further tests, however we can conclude here that although maintaining a trading relationship is on average costly, in times of liquidity events and credit events, the relationship really pays off, as shown in Figure 3 and Figure 4.

[Figure 3-4]

Figure 3-4 graphs the predictive margins of the interaction term *PrimeMMF*Post-Reform*Relation*, with *Post-Reform* as *After*. Figure 3 is using *NSAR-TOP3* as *Relation*, Figure 4 is using *Volume1m* as *Relation*. *After* equals 0 for the 1 year before the MMF reform. *After* equals 1 for the 1 year after the MMF reform. Figure 3-4 intuitively shows that relationship funds act as liquidity insurers and keep the repo rate markup stable after the MMF reform, as the yellow line is relatively flat. But non-relationship funds significantly raised the repo rate markup after the MMF reform, causing the green line to shoot up higher than the yellow line. As for control groups (non-

Prime funds, not affected by the MMF reform), the red and blue line stays relatively flat. This also means that relationship Prime MMFs, even when hit by a liquidity shock, will absorb the shock so that linked dealers can enjoy stable short-term rate environment, like linked dealers of control group funds.

IV. Search Cost: the case of Schwab Sweep Fund Liquidation

To check the robustness of our result, we have shown the "Skin in the Game" hypothesis in Table 3 cannot explain why relationship MMFs lend more to linked dealers at favorable interest rates after MMF Reform. Therefore, the liquidity insurance hypothesis hold. But as Li, Lu & Srinivasan (2019) have shown, big borrowing firms will have alternative source of funding. Therefore, in times of borrower stress, lender does not provide liquidity insurance, so they argue that banks are not helping firms in times of stress.

The borrowers in our framework are all large dealers who have all sorts of alternative source of funding. So for our story to hold, search cost must be high enough to make sure the dealers don't switch randomly among all other funds. To estimate the search cost, we introduce another quasi-natural experiment that involves Charles Schwab's unexpected announcement that they are switching their Sweep Funds to bank deposit products, reducing the yield provided to investors from 2% in April.2018 to 0.65% from bank deposits.

[Table 7-8]

Table 7 shows the 3 now liquidated funds in the Schwab Sweep family, and their respective linked dealers. We can see that over time in our sample, and across funds, the linked dealers to Schwab

Sweep Fund Family is almost the same, confirming our finding that trading partnerships are stable over time. In Table 8, we can see that the most affected dealers by Schwab Sweep's sudden liquidation, in terms of total % of repo trades placed with Schwab Sweep Funds.

[Table 9]

Table 9 use this event as a quasi-natural experiment, and estimated the search cost for the 4 most affected dealers, after the Schwab Sweep liquidation. *Affected_Dealers* equals 1 if the linked dealer is any of the 4: Credit Suisse, Barclays, Royal Bank of Canada and Wells Fargo. After the Schwab liquidation (*Post_Liquidation* equals 1), the 4 affected dealers are most affected, with a repo rate markup of ~3 basis points, compared to the control group dealers. In other words, even though the whole tri-party repo market has a liquidity shock (Schwab Sweep exit the market), other non-linked dealers are not as severely impacted as the 4 linked dealers. It's consistent with our hypothesis that search cost and insurance needs incentivize dealers to form stable relationship with the funds. The result can be shown intuitively in Figure 5.

[Figure 5]

V. Conclusion

In this paper we construct a novel dataset combining N-MFP forms and N-SAR forms to yield a complete trading network between Money Market Funds(MMFs) and dealers. We identify each fund-dealer pair and investigate how their relationship change over time can affect repo rates and repo haircuts in US tri-party repo market. We test the prediction that over-the-counter search friction incentivize dealers to pay a liquidity insurance premium to their relationship money market funds (MMFs). In case of a market wide liquidity shortage, dealers can still obtain funds from their relationship funds at favorable terms, thus effectively smoothing out the negative shock. Using the Oct.2016 MMF Reform, we confirm our hypothesis that dealers are paying an insurance premium of around ~8bps before the MMF reform. But relationship MMFs provide favorable trading terms to linked dealers after the reform. Therefore, Prime MMFs are playing the role of liquidity insurers. We also find the trading relationships are stable over time. In the liquidation case of Charles Schwab Money Market Sweep Funds, 4 most affected dealers had to bear ~3bps more markup than control group dealers, because they need to search for new relationship funds.

These findings imply relationship bundling might exacerbate the next crisis if MMFs experience fund runs. In our sample, the Fidelity Prime Funds and Fidelity Government Funds significantly out-lend other funds, both in repo trade frequency and repo trade volume. If Fidelity experience extreme outflow, then its most connected dealers will have difficulty borrowing the money to roll-over their short-term debt, which will again lead to the repo market turmoil as we have seen in 2008, and most recently Sept.2019. In addition, dealers will fire sale their long term assets if they have difficulty rolling over their short-term financings such as the tri-party repo. As a result, dealers will keep buying this liquidity insurance to keep daily operation smooth so that they can reap the yield difference. Whether Fidelity is “too big to fail” is not so obvious, and we will leave that to future researchers.

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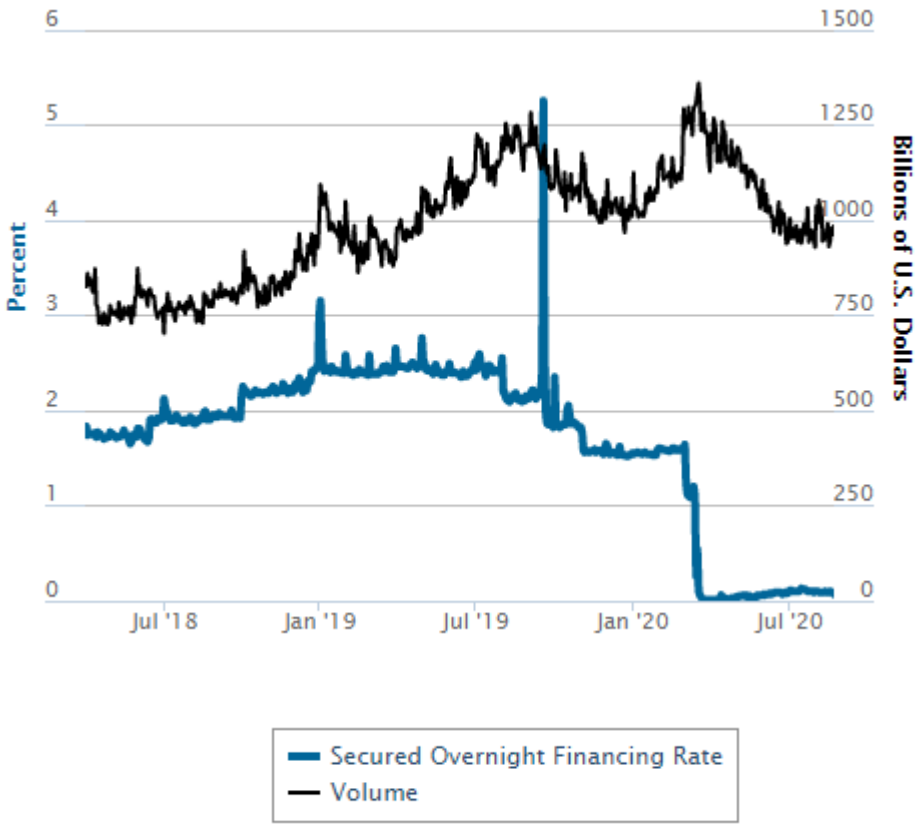
Figure 1. A Short-term Interest Rate Benchmark: Federal Reserve's SOFR Rate



Source: Federal Reserve SOFR website

Figure 2. Summary of Repo Trades in US Tri-party Repo Market

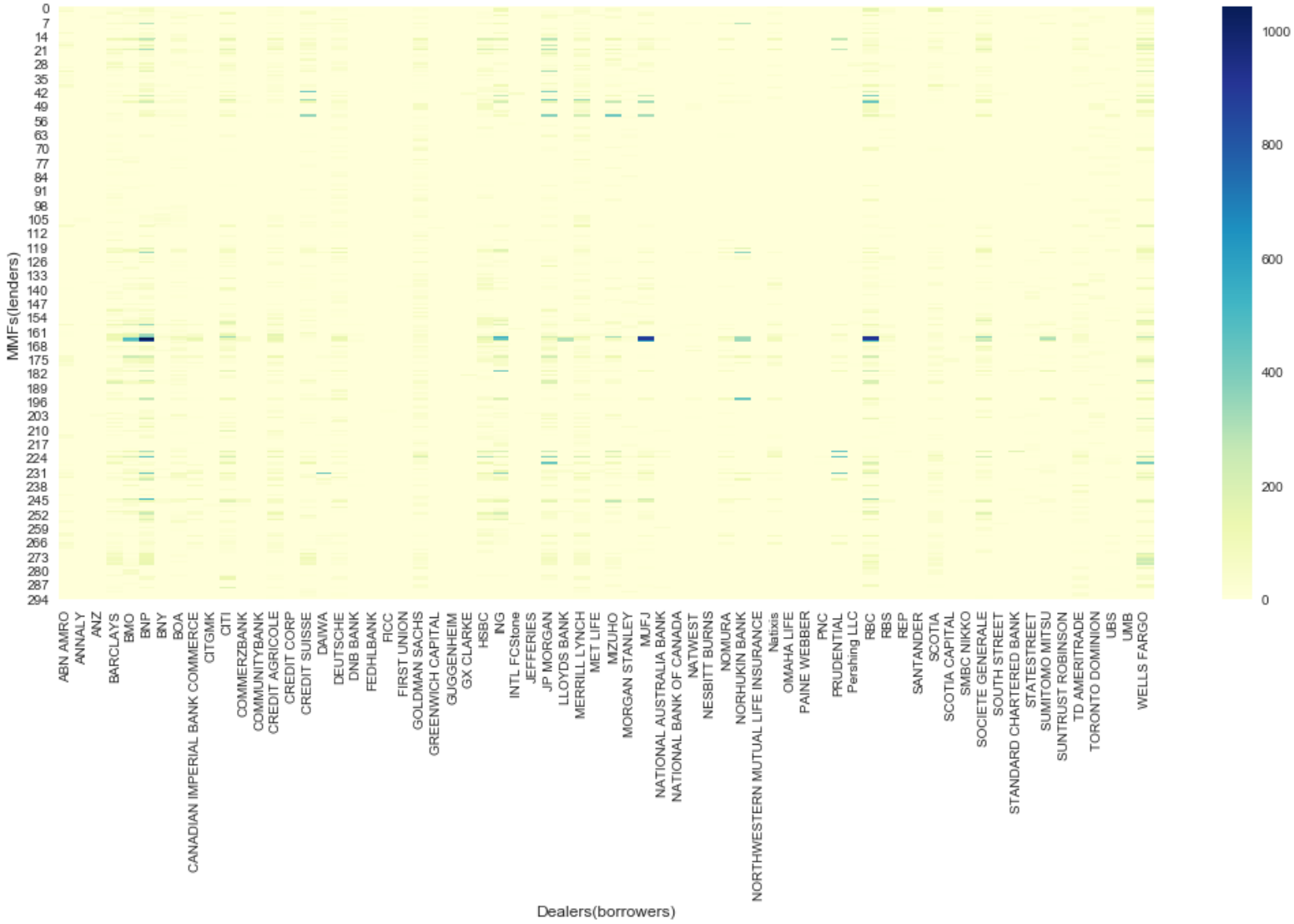


Figure 3. Predictive Margin of the Interaction Term: Trading Based Relationship

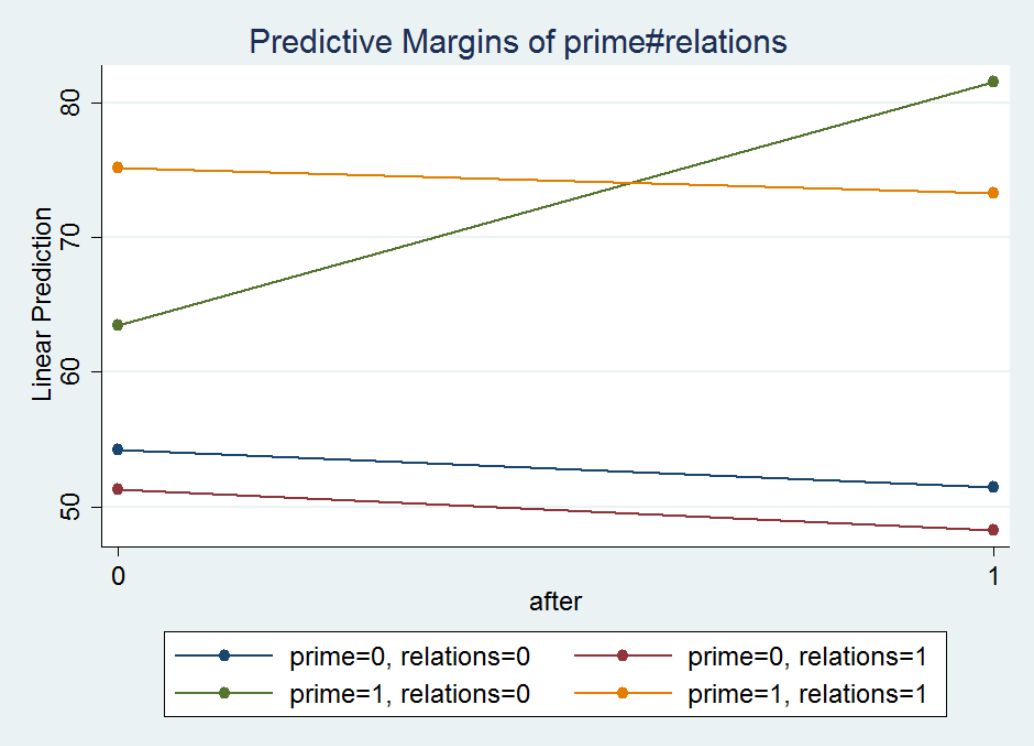


Figure 4. Predictive Margin of the Interaction Term: NSAR Based Relationship

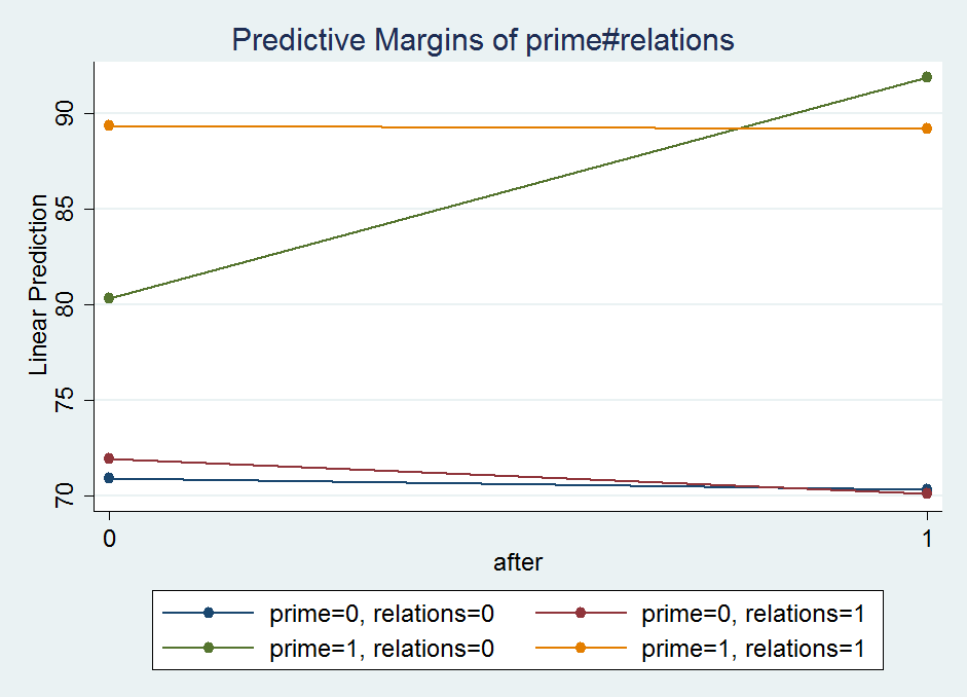


Figure 5. Charles Schwab Sweep Liquidation Shock

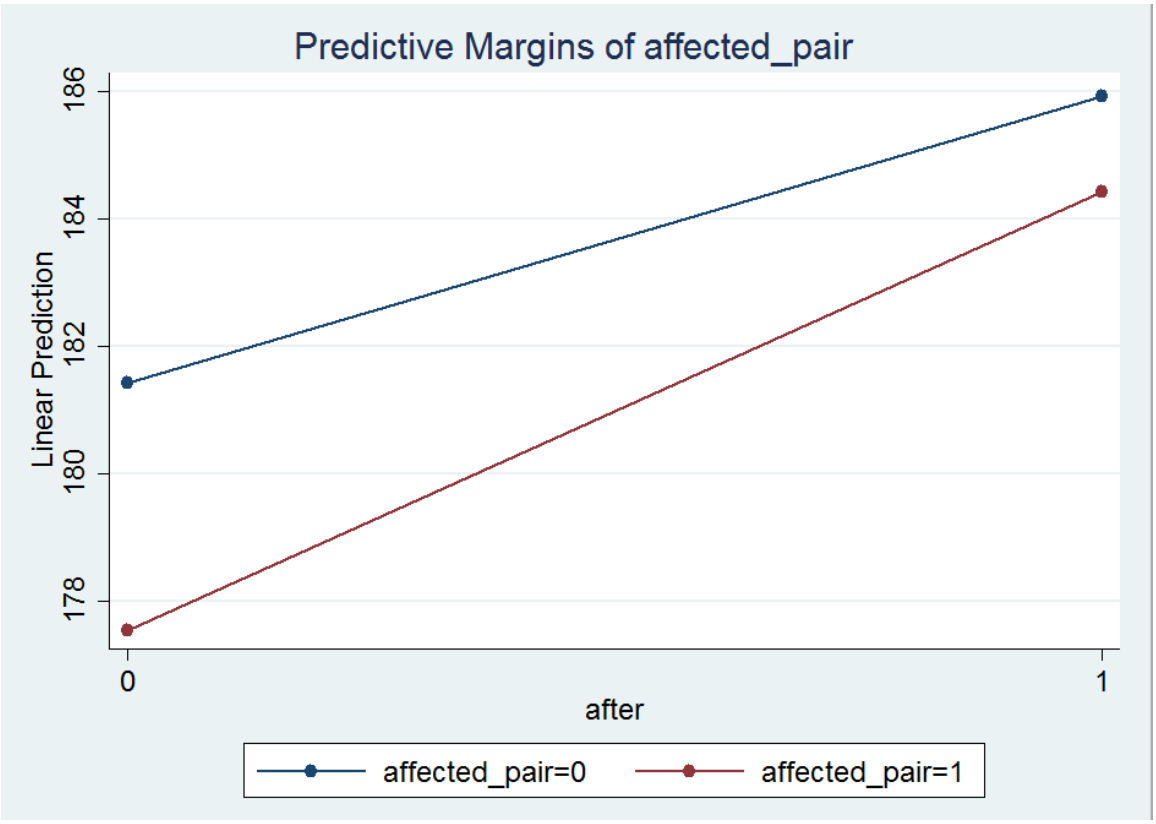


Table 1 Summary Statistics

Table 1 shows the summary statistics of repo trade terms, fund characteristics, dealer characteristics, and general market liquidity condition. RepoRate is the repo rate reported on a given repo transaction. Principal is the total money borrowed by the dealer/lent by the fund on a given repo transaction. Tenor is the maturity on a repo transaction. Fed Rate is the Federal Funds Rate, which is the benchmarking short-term interest rates. Fund Size is the total amount lent out by a fund in a given month. Dealer Size is the total amount borrowed by a dealer in a given month. Sample Period: Oct.2015-Oct.2017.

Relationship=1

	Mean				
	Pre-Reform	Post-Reform	Diff.	Std. Error	Obs.
RepoRate	**42.45**	**87.70**	**45.25*****	0.57	10439
Principal	**3.87**	**4.19**	**0.32*****	0.04	10439
Illiquid	0.23	0.22	-0.01	0.01	10439
Tenor	12.85	13.03	0.18	0.44	10439
Fed Rate	32.87	88.75	55.88***	0.43	10439
Fund Size	1.17	3.84	2.66***	0.08	10439
Dealer Size	5.31	5.58	0.28***	0.10	10439

Relationship=0

	Mean				
	Pre-Reform	Post-Reform	Diff.	Std. Error	Obs.
RepoRate	**38.02**	**93.37**	**55.35*****	0.52	14155
Principal	**3.99**	**4.28**	**0.29*****	0.03	14155
Illiquid	0.11	0.12	0.01	0.01	14155
Tenor	6.33	6.95	0.62**	0.29	14155
Fed Rate	32.32	93.64	61.32***	0.37	14155
Fund Size	0.91	2.20	1.29***	0.06	14155
Dealer Size	4.10	3.93	-0.17**	0.07	14155

Table 2. Baseline Regression

VARIABLES	(1) volume1m	(2) volume3m	(3) count1m	(4) count3m
Relationship	0.66**	0.74***	-0.08	0.10
	(0.26)	(0.26)	(0.38)	(0.36)
Principal	0.98***	0.97***	1.01***	1.00***
	(0.20)	(0.20)	(0.19)	(0.19)
Illiquid	16.29***	16.27***	16.30***	16.21***
	(2.32)	(2.31)	(2.32)	(2.32)
Tenor	0.10***	0.10***	0.10***	0.10***
	(0.03)	(0.03)	(0.03)	(0.03)
Fed Rate	0.72***	0.70***	0.75***	0.68***
	(0.25)	(0.25)	(0.24)	(0.24)
Fund Size	-1.64***	-0.53***	-7.66***	-2.10***
	(0.32)	(0.11)	(1.07)	(0.31)
Dealer Size	-0.11*	-0.09**	-0.20	-0.31***
	(0.06)	(0.04)	(0.18)	(0.09)
Constant	21.50***	21.92***	21.46***	22.63***
	(2.86)	(2.88)	(2.62)	(2.79)
Observations	139,027	139,027	139,027	139,027
R-squared	0.94	0.94	0.94	0.94
# of cluster	290	290	290	290
Time FE	YES	YES	YES	YES
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table 3. Skin in the Game

VARIABLES	(1) dealer_ct_%	(2) dealer_vlm_%	(3) fund_ct_%	(4) fund_vml_%
Relationship	1.99**	3.91***	1.53	-0.06
	(0.87)	(0.74)	(1.54)	(1.27)
Principal	1.03***	0.95***	1.01***	1.03***
	(0.19)	(0.20)	(0.19)	(0.20)
Illiquid	16.29***	16.32***	16.28***	16.25***
	(2.32)	(2.31)	(2.32)	(2.32)
Tenor	0.10***	0.10***	0.10***	0.10***
	(0.03)	(0.03)	(0.03)	(0.03)
Fed Rate	0.77***	0.77***	0.72***	0.72***
	(0.25)	(0.25)	(0.24)	(0.24)
Fund Size	-7.46***	-1.43***	-7.80***	-1.62***
	(1.01)	(0.30)	(1.05)	(0.31)
Dealer Size	-0.23	-0.11*	-0.18	-0.10*
	(0.18)	(0.06)	(0.18)	(0.06)
Constant	20.77***	20.42***	21.60***	21.40***
	(2.68)	(2.87)	(2.58)	(2.81)
Observations	139,027	139,008	139,027	139,027
R-squared	0.94	0.94	0.94	0.94
# of cluster	290	290	290	290
Time FE	YES	YES	YES	YES
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table 4. Prime Money Market Reform in Oct.2016

VARIABLES	(1) base1	(2) base2	(3) NSAR_top3	(4) NSAR_rank	(5) volume1m	(6) volume3m	(7) count1m	(8) count3m
PostReform	-0.27	-1.00	-0.96	-0.96	-1.00	-0.94	-1.09	-1.14
	(0.80)	(0.68)	(0.70)	(0.70)	(0.68)	(0.70)	(0.66)	(0.72)
PrimeMMF		8.04**	8.91***	8.84***	8.04**	8.98***	8.07***	9.00***
		(3.10)	(3.04)	(3.05)	(3.10)	(3.02)	(2.99)	(3.10)
PrimeMMF*PostReform		12.19***	12.12***	12.13***	12.19***	12.18***	11.64***	12.14***
		(2.74)	(2.69)	(2.68)	(2.75)	(2.64)	(2.78)	(2.81)
Relationship			0.55	0.05	-0.00	0.48	-1.65***	-1.70***
			(0.48)	(0.06)	(0.43)	(0.48)	(0.46)	(0.49)
Principal	1.15***	1.27***	1.24***	1.25***	1.27***	1.21***	1.20***	1.20***
	(0.23)	(0.22)	(0.22)	(0.22)	(0.22)	(0.21)	(0.22)	(0.22)
Illiquid	11.85***	11.90***	12.11***	12.11***	11.90***	12.14***	12.09***	12.09***
	(4.06)	(4.03)	(3.99)	(3.99)	(4.07)	(4.03)	(3.99)	(3.98)
Tenor	0.24***	0.24***	0.25***	0.25***	0.24***	0.24***	0.25***	0.25***
	(0.08)	(0.07)	(0.07)	(0.07)	(0.08)	(0.07)	(0.07)	(0.07)
Fed Rate	0.97***	0.97***	0.96***	0.96***	0.97***	0.96***	0.97***	0.96***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Fund Size	-1.75**	-0.73***	-0.14	-0.14	-0.73***	-0.14	-2.06	-0.07
	(0.77)	(0.25)	(0.11)	(0.11)	(0.25)	(0.11)	(1.27)	(0.47)
Dealer Size	-0.38***	-0.36***	-0.24***	-0.25***	-0.36***	-0.25***	-0.36**	-0.02
	(0.06)	(0.06)	(0.04)	(0.04)	(0.06)	(0.04)	(0.15)	(0.10)
Constant	19.22***	16.15***	16.79***	16.77***	16.15***	16.84***	16.78***	16.23***
	(3.06)	(2.46)	(2.43)	(2.43)	(2.46)	(2.44)	(2.43)	(2.51)
Observations	24,613	24,613	24,613	24,613	24,613	24,613	24,613	24,613
# of clusters	199	199	199	199	199	199	199	199
Adjusted R-squared	0.84	0.84	0.84	0.84	0.84	0.84	0.84	0.84
RepoType FE	YES	YES	YES	YES	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES	YES	YES	YES	YES

Table 5. RepoRate Diff-in-Diff : Trading Based Relationship Ranking

VARIABLES	(3) volume1m	(4) volume3m	(1) count1m	(2) count3m
PostReform	-0.82	-0.74	-0.91	-0.50
	(0.64)	(0.66)	(0.69)	(0.73)
PrimeMMF	4.40	5.32*	3.81	3.59
	(3.35)	(3.20)	(3.44)	(3.72)
PostReform*PrimeMMF	15.72***	15.66***	15.27***	16.76***
	(2.98)	(2.78)	(3.11)	(3.45)
PostReform*Relationship	-0.40	-0.42	-0.44	-1.36
	(0.64)	(0.62)	(0.86)	(0.89)
Relationship	0.12	0.59	-1.69**	-1.13
	(0.65)	(0.69)	(0.78)	(0.84)
PrimeMMF*Relationship	8.67***	9.58***	9.49***	10.69***
	(1.04)	(1.12)	(1.19)	(1.28)
PrimeMMF*Relationship*PostReform	**-8.89*** **	**-9.26*** **	**-3.14**	**-7.34** **
	(1.13)	**(1.73)**	**(3.04)**	**(2.90)**
Principal	1.28***	1.22***	1.20***	1.21***
	(0.22)	(0.21)	(0.22)	(0.22)
Illiquid	11.79***	12.00***	12.11***	12.10***
	(4.03)	(3.98)	(3.98)	(3.97)
Tenor	0.24***	0.25***	0.25***	0.25***
	(0.08)	(0.07)	(0.08)	(0.07)
Fed Rate	0.97***	0.96***	0.97***	0.96***
	(0.01)	(0.01)	(0.01)	(0.01)
Fund Size	-0.73***	-0.14	-1.98	-0.01
	(0.25)	(0.11)	(1.29)	(0.48)
Dealer Size	-0.36***	-0.25***	-0.35**	-0.01
	(0.06)	(0.04)	(0.15)	(0.10)
Constant	16.14***	16.81***	16.68***	15.83***
	(2.40)	(2.38)	(2.41)	(2.47)
Observations	24,613	24,613	24,613	24,613
# of clusters	199	199	199	199
Adjusted R-squared	0.84	0.84	0.84	0.84
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table 6. RepoRate Diff-in-Diff : NSAR Based Relationship Ranking

VARIABLES	(1) NSAR_top3	(2) NSAR_top5	(3) NSAR_top10	(4) NSAR_rank
PostReform	-0.85	-0.73	-1.01	-0.81
	(0.74)	(0.75)	(0.69)	(0.74)
PrimeMMF	8.01**	7.70***	6.81*	7.35**
	(3.21)	(2.75)	(3.65)	(3.55)
PostReform*PrimeMMF	12.97***	13.28***	13.69***	12.95***
	(2.85)	(2.20)	(3.07)	(3.03)
PostReform*Relationship	-0.66	-0.92	0.18	-0.04
	(0.76)	(0.72)	(0.62)	(0.08)
Relationship	1.35**	1.15	-0.31	0.06
	(0.68)	(0.78)	(0.61)	(0.09)
PrimeMMF*Relationship	6.81***	7.06***	8.87***	1.18***
	(1.30)	(1.31)	(1.31)	(0.19)
PrimeMMF*Relationship*PostReform	**-8.80*** **	**-10.17*** **	**-7.87*** **	**-0.83***
	(2.38)	**(2.92)**	**(2.54)**	**(0.47)**
Principal	1.24***	1.24***	1.26***	1.25***
	(0.22)	(0.22)	(0.22)	(0.22)
Illiquid	12.06***	12.07***	11.99***	12.05***
	(3.97)	(3.98)	(3.96)	(3.96)
Tenor	0.25***	0.25***	0.25***	0.25***
	(0.07)	(0.07)	(0.07)	(0.07)
Fed Rate	0.96***	0.96***	0.96***	0.96***
	(0.01)	(0.01)	(0.01)	(0.01)
Constant	16.79***	16.75***	16.90***	16.76***
	(2.43)	(2.45)	(2.40)	(2.42)
Observations	24,613	24,613	24,613	24,613
# of clusters	199	199	199	199
Adjusted R-squared	0.84	0.84	0.84	0.84
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table 7. Forced Partner Switch: Affected Dealers in Charles Schwab MMF Liquidation

Liquidation Date		
2018-04	2018-09	2019-03
SWMXX-BARCLAYS	SWQXX-BARCLAYS	SWSXX-BARCLAYS
SWMXX-BMO	SWQXX-BMO	SWSXX-BMO
SWMXX-BNP	SWQXX-BNP	SWSXX-BNP
SWMXX-CREDIT AGRICOLE	SWQXX-CREDIT AGRICOLE	SWSXX-CREDIT AGRICOLE
SWMXX-CREDIT SUISSE	SWQXX-CREDIT SUISSE	SWSXX-CREDIT SUISSE
SWMXX-DEUTSCHE	SWQXX-DEUTSCHE	SWSXX-DEUTSCHE
SWMXX-GOLDMAN SACHS	SWQXX-GOLDMAN SACHS	SWSXX-GOLDMAN SACHS
SWMXX-JP MORGAN	SWQXX-JP MORGAN	SWSXX-JP MORGAN
SWMXX-MERRILL LYNCH	SWQXX-MERRILL LYNCH	SWSXX-MERRILL LYNCH
SWMXX-MIZUHO	SWQXX-MIZUHO	SWSXX-MIZUHO
	SWQXX-MORGAN STANLEY	
SWMXX-RBC	SWQXX-RBC	SWSXX-RBC
SWMXX-SCOTIA	SWQXX-SCOTIA	SWSXX-SCOTIA
SWMXX-WELLS FARGO	SWQXX-WELLS FARGO	SWSXX-WELLS FARGO

Table 8. Partner Importance: 4 Most Affected Dealers in Charles Schwab MMF Liquidation

	Repo Trade with Charles Schwab/Total Repo Trade (%)
CREDIT SUISSE	**9%**
WELLS FARGO	**6%**
BARCLAYS	**4%**
RBC	**4%**
SCOTIA	3%
BNP	2%
MERRILL LYNCH	2%
MIZUHO	2%
JP MORGAN	2%
BMO	1%
CREDIT AGRICOLE	1%
GOLDMAN SACHS	1%

Table 9. RepoRate Diff-in-Diff: Charles Schwab Liquidation Case

VARIABLES	(1) affected	(2) affected	(3) affected
Post_Liquidation	2.89***	2.89***	2.81***
	(0.49)	(0.49)	(0.48)
Affected_Dealers		-2.21**	-3.81***
		(1.07)	(1.08)
Affected_Dealers*Post_Liquidation			**2.76*** **
			(0.65)
Principal	0.65*	0.65*	0.65*
	(0.37)	(0.37)	(0.37)
Illiquid	16.53***	16.53***	16.53***
	(4.89)	(4.89)	(4.89)
Tenor	0.10	0.10	0.10
	(0.08)	(0.08)	(0.08)
Fed Rate	1.13***	1.13***	1.13***
	(0.01)	(0.01)	(0.01)
Fund Size	-0.43***	-0.43***	-0.43***
	(0.14)	(0.14)	(0.14)
Dealer Size	0.31	0.31	0.31
	(0.20)	(0.20)	(0.20)
Constant	1.95	2.01	2.05
	(2.96)	(2.96)	(2.96)
Observations	56,713	56,713	56,713
Number of ticker_code	53	53	53
RepoType FE	YES	YES	YES
Dealer FE	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Appendix: Repo Haircuts

Table A1. Haircut Baseline Regressions: Trading Based Ranking

	(1)	(2)	(3)	(4)
VARIABLES	volume1m	volume3m	count1m	count3m
Relationship	0.12***	0.13***	0.12***	0.12***
	(0.03)	(0.03)	(0.03)	(0.03)
Principal	0.03**	0.03**	0.05***	0.05***
	(0.02)	(0.02)	(0.02)	(0.02)
Illiquid	0.44***	0.44***	0.43***	0.43***
	(0.16)	(0.16)	(0.16)	(0.16)
Tenor	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)
Fed Rate	-0.11**	-0.11**	-0.11**	-0.11**
	(0.05)	(0.05)	(0.05)	(0.05)
Fund Size	0.09**	0.03**	0.40***	0.12***
	(0.04)	(0.01)	(0.12)	(0.04)
Dealer Size	0.00	0.00	0.02	0.01
	(0.00)	(0.00)	(0.01)	(0.01)
Constant	7.10***	7.08***	7.06***	7.02***
	(0.72)	(0.72)	(0.71)	(0.71)
Observations	138,991	138,991	138,991	138,991
R-squared	0.46	0.46	0.46	0.46
# of clusters	290	290	290	290
Time FE	YES	YES	YES	YES
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table A2. Haircut Baseline Regressions: NSAR Based Ranking

VARIABLES	(1) NSAR_top1	(2) NSAR_top3	(3) NSAR_top5	(4) NSAR_top10	(5) NSAR_rank
Relationship	0.35***	0.31***	0.31***	0.19***	0.04***
	(0.10)	(0.07)	(0.07)	(0.06)	(0.01)
Principal	0.04***	0.04**	0.04**	0.04***	0.04***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Illiquid	0.44***	0.45***	0.45***	0.44***	0.45***
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Tenor	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fed Rate	-0.11**	-0.11**	-0.11**	-0.11**	-0.11**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Fund Size	0.03**	0.03**	0.03**	0.03**	0.03**
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Dealer Size	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Constant	7.06***	7.14***	7.14***	7.12***	7.13***
	(0.72)	(0.72)	(0.72)	(0.73)	(0.72)
Observations	138,991	138,991	138,991	138,991	138,991
R-squared	0.46	0.46	0.46	0.46	0.46
# of clusters	290	290	290	290	290
Time FE	YES	YES	YES	YES	YES
RepoType FE	YES	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table A3. Haircut Baseline Regressions: Skin in the Game

	Past 1-month				Past 3-month			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES	dealer_ct_%	dealer_vlm_%	fund_ct_%	fund_vlm_%	dealer_ct_%	dealer_vlm_%	fund_ct_%	fund_vlm_%
Relationship	0.23	0.19	0.23**	0.20***	0.19**	0.00	0.22**	0.08***
	(0.17)	(0.16)	(0.10)	(0.07)	(0.08)	(0.00)	(0.08)	(0.03)
Principal	0.04***	0.04***	0.05***	0.04**	0.05***	0.04***	0.05***	0.04***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
Illiquid	0.43***	0.44***	0.43***	0.44***	0.44***	0.44***	0.42***	0.43***
	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)	(0.16)
Tenor	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Fed Rate	-0.11**	-0.11**	-0.11**	-0.10**	-0.11**	-0.10**	-0.10**	-0.11**
	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)	(0.05)
Fund Size	0.44***	0.09**	0.48***	0.10**	0.13***	0.03**	0.15***	0.03**
	(0.13)	(0.04)	(0.13)	(0.05)	(0.04)	(0.01)	(0.04)	(0.02)
Dealer Size	0.03***	0.01	0.02**	0.00	0.02**	0.00	0.01	0.00
	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)	(0.01)	(0.00)
Constant	7.08***	7.12***	6.97***	7.03***	7.03***	7.05***	6.95***	7.05***
	(0.71)	(0.71)	(0.69)	(0.72)	(0.71)	(0.72)	(0.70)	(0.73)
Observations	138,991	138,991	138,991	138,973	137,282	137,847	137,006	137,006
R-squared	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Number of ticker_code	290	290	290	290	290	290	290	290
Time FE	YES	YES	YES	YES	YES	YES	YES	YES
RepoType FE	YES	YES	YES	YES	YES	YES	YES	YES
Fund-Dealer Pair FE	YES	YES	YES	YES	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.

Table A4. Haircut Diff-in-Diff: Trading Based Relationship Ranking

VARIABLES	(1) volume1m	(2) volume3m	(3) count1m	(4) count3m
PostReform	0.38***	0.41***	0.31***	0.32***
	(0.09)	(0.09)	(0.12)	(0.12)
PrimeMMF	-2.88***	-2.92***	-2.14***	-2.26***
	(0.47)	(0.45)	(0.40)	(0.42)
PostReform*PrimeMMF	0.82***	0.82***	0.20	0.28
	(0.29)	(0.30)	(0.26)	(0.29)
PostReform*Relationship	0.16*	0.12	0.30***	0.27***
	(0.09)	(0.10)	(0.10)	(0.10)
Relationship	0.22**	0.28***	0.01	0.04
	(0.09)	(0.08)	(0.09)	(0.07)
PrimeMMF*Relationship	1.53***	1.69***	0.01	0.15
	(0.23)	(0.23)	(0.17)	(0.16)
PrimeMMF*Relationship*PostReform	**-1.81*** **	**-1.97*** **	0.47	-0.16
	(0.46)	**(0.62)**	(0.64)	(0.61)
Principal	0.00	-0.00	0.03	0.03
	(0.02)	(0.02)	(0.03)	(0.03)
Illiquid	-0.09	-0.09	-0.13	-0.13
	(0.26)	(0.25)	(0.27)	(0.27)
Tenor	0.02***	0.02***	0.02***	0.02***
	(0.01)	(0.01)	(0.01)	(0.01)
Fund Size	0.00	-0.00	0.14	0.03
	(0.08)	(0.02)	(0.11)	(0.05)
Dealer Size	-0.01	-0.00	0.01	-0.01
	(0.01)	(0.00)	(0.03)	(0.02)
Constant	7.04***	7.04***	6.92***	6.97***
	(0.57)	(0.56)	(0.56)	(0.57)
Observations	24,578	24,578	24,578	24,578
# of clusters	200	200	200	200
Adjusted R-squared	0.51	0.51	0.51	0.51
RepoType FE	YES	YES	YES	YES
Fund FE	YES	YES	YES	YES

Clustered standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.