Trading Relationships in the OTC Market for Secured Claims: Evidence from Triparty Repos*

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Preliminary. Please do not distribute.

Abstract

We use a new panel dataset on intraday transactions of triparty repos to study trading relationships in the over-the-counter market. We test the prediction that search frictions lead to relationship formation. We find that TPR trading parties form relationships with a broad number of counterparties, but tend to focus their transaction volumes to only a small set of counterparties—those with whom they have broader interactions across both TPR and other funding markets. We also find that relationships affect the likelihood of a trade and terms of trade, and help buffer demand and supply shocks to liquidity. Specifically, the Fed's RRPs exercise draws funds away from lenders in the TPR market, effectively generating a negative shock to the supply of funds for dealers. Meanwhile, Treasury auctions introduce a positive shock to the demand for funds by dealers. We find that in both cases, shocks are absorbed better by trade partners with stronger relationships.

JEL Classifications: G12, G24, E58
Key words: Triparty repos, OTC markets, trade relationships, RRP exercises, Treasury Auctions, search frictions

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1 Introduction

In an over-the-counter (OTC) market, buyers and sellers search and meet to bargain over the terms of trades. A vast range of securities, including most fixed income instruments and derivatives, are traded through this trading mechanism instead of centralized platforms such as exchanges or auctions. Theoretically, it is well recognized that search frictions affect investor behavior and trade outcomes in these markets (Duffie, 2012). Particularly, one important implication of search frictions is that trading parties may form stable relationships to mitigate the effect of search costs or asymmetric information. Empirically, several recent studies document an important role of trading relationships in the interbank markets—OTC markets, such as the Federal Funds market, where banks trade unsecured claims on their excess reserves (Ashcraft and Duffie, 2007; Afonso et al., 2014).

In this paper we study the quantitative importance of trading relationship in an OTC market for secured claims—the U.S. triparty repo (TPR) market. The TPR market, with the size of about $1.6 trillion as of September 30, 2015, is a major funding platform for securities dealers, who borrow cash to fund their portfolio of securities, and an important investment vehicle for cash investors such as money market mutual funds (MMFs) and securities lenders. Unlike the interbank markets that trade unsecured claims, TPR transactions are effectively secured by mostly high-quality collateral, such as Treasury securities, mitigating the concerns about asymmetric information on counterparty credit risk (Mills and Reed, 2008; Infante, 2015; Hu et al., 2015). In addition, participants of the TPR market are generally large, sophisticated, and well-known financial institutions. Thus, the costs of locating a given trade partner and setting up the related contractual infrastructure should be relatively small. In this context, is there still a role for trading relationships in the TPR market? If so, how are the relationships formed? How do trading relationships affect terms of trade and, in particular, mitigate liquidity shocks?

Taking advantage of a new dataset covering TPR transactions over the period from September 2012 to June 2015, we shed light on these questions by examining trading relationships between MMFs and securities dealers, who are key participants in this market. First, we find that trade parties, particularly larger ones, form stable relationships with a broad set of counterparties but tend to concentrate their transactions on far fewer ones. Speaking to the breadth of trading relationships, the TPR trade volume of MMFs, which only have a trading relationship with one dealer is only eleven percent of the overall TPR volume in our sample. For dealers, this number is less than one percent. This means that MMFs trade with multiple dealers and vice versa. Indeed, an average investor would form four relationships, whereas an average dealer would form twelve. Regarding the strength of trading relationships, we adopt the commonly-used approach to measure the strength of a relationship between a MMF and a dealer by the concentration of the MMF's total lending to the dealer or the concentration of the dealer's total borrowing from the MMF (see, e.g, Petersen and Rajan (1994); Ashcraft and Duffie (2007); Afonso et al. (2014)). So the higher the concentration, the stronger the relationship. We find that, while maintaining trading with a broad set of counterparties, trade parties tend to allocate greater amount of volumes to some "preferred" ones. In addition, "preferred" counterparties and relationships are stable over time, in that relationship formation depends positively on their previous dependence in the same market, a result in line with Copeland et al. (2012).

Second, we find that the strength of trading relationships in the TPR market depends positively on the overall interactions across other business areas in the lender-borrower pair, suggesting economies of scale in relationship formation. Our test in this regard is motivated by the relationship lending literature, which suggests that informational frictions can be mitigated by increasing the scope of interactions across different products and over time (see, for example, Petersen and Rajan (1994)). The TPR market is dominated by a few large MMFs and dealers who may interact in multiple businesses. MMFs invest not just in repos but also in other instruments, such as commercial paper (CP) and certificates of deposits (CDs), that dealers intermediate or issue. As such, counterparties may form stable relationships in the TPR market if it helps to achieve their overall strategic complementarity across markets and overall profitability. Our results support this prediction as we find that MMFs with larger overall lending to a specific dealer across various markets form a stronger relationship with that dealer in the TPR market.

Our finding of economies of scale in trading across markets may help reconcile the seemingly contradictory results in previous TPR studies. Specifically, on the one hand, (Hu et al., 2015) find that the creditworthiness of the borrower does not affect the terms of TPR trades.[1] On the other hand, (Copeland et al., 2014) find that the identity of the borrower does matter for terms of trade. Our results suggests that the dealer's identity matters because it represents the breadth of the scope of interactions with lenders. In the context of such broad interactions good credit quality may not appear to matter, because it is already part of the factors that the lenders take into account to form the trading relationship.

Finally, we find that trading relationships affect terms of trades and, importantly, help absorb shocks to both demand for and supply of liquidity in the TPR market. Previous theoretical studies suggest that stronger relationships reduce search costs and increase ability to withstand liquidity shocks (Duffie et al., 2005, 2007; Vayanos and Weill, 2008; Weill, 2008; Lagos and Rocheteau, 2009). Empirical results in the federal funds market support these theoretical predictions (Ashcraft and Duffie, 2007; Afonso et al., 2014). Therefore, we hypothesize that in the TPR market, all else being equal, liquidity shocks would have a milder impact on pairs with stronger relationships.

We use two types of quasi-natural experiments to identify the effects that shocks to the demand for, and the supply of, repo funding may affect the role of relationships in the TPR market. Our first experiment is Treasury auctions. While primary dealers are the main buyers at these auctions, other securities dealers may also take part in the auctions directly.

[1] Hu et al. (2015) use transactions level data obtained from the monthly reports of MMFs to the SEC. They examine repo rates (spreads), volumes and haircuts with respect to collateral types and borrower creditworthiness. In contrast to our daily data, they observe snapshots at month-ends and have only a subset of repo transactions (because not all MMFs report their holdings). They also include quarter-end dates, which contain different pricing dynamics due to regulatory reasons. Their paper is closely related to Krishnamurthy et al. (2014), who find evidence of a run in the TPR market using less refined data (the quarterly reports of the top 20 MMF families (N-CSR, N-CSRS and N-Q) before the 2010 TPR reform).

A key funding source for dealers to purchase Treasury issuance is the TPR market. Thus, a new Treasury auction leads to an exogenous increase in dealers' demand for TPR borrowing. Our second experiment is the Fed's overnight reverse repurchase (ON RRP) exercises. As a tool in the normalization of monetary policy, the Fed has been testing ON RRPs since September 2013, where it effectively borrows from a selected group of eligible cash investors (RRP counterparties), up to a cap at a given offer rate, in the TPR market. Therefore, all else being equal, the introduction of ON RRPs essentially reduces the supply of funds to the private dealers.

In both settings we find that trading relationships affect significantly the outcome of a trade and, importantly, help absorb liquidity shocks. In terms of shock absorption, when dealers face positive shocks to the demand for repo funding, as needed to fund Treasury auction purchases, the MMFs with stronger relationships with dealers are the ones who are funding the larger amounts at more favorable rates for those dealers. In addition, we find that the Fed's ON RRPs lead to a decline in the supply of funds to dealers. It appears that, following the RRP, MMFs replaced private repos (repos with dealers) with RRP (repos with the Fed), and such substitution increased with higher RRP caps and the attractiveness of RRP offer rates relative to market rates. However, MMFs with stronger relationships with dealers tend to be less sensitive to RRP terms in that their reduction in lending to dealers was smaller and they are remunerated for their "loyalty" by marginally higher rates. In that sense, RRP appears to increase the bargaining power of MMFs, albeit marginally.

Our paper contributes to the nascent quantitative studies on the OTC trading mechanism. To the best of our knowledge, our study provides the first direct analysis on trading relationships in a secured market using transactions data. This is important because trading relationships have been thought mainly as a tool to mitigate information frictions in the absence of quality collateral. The emerging studies on the OTC trading mechanism have mostly focused on relationship formation in the interbank market where banks trade excess reserves to meet daily reserve requirements (Ashcraft and Duffie, 2007; Afonso et al., 2014)

As the claims traded are unsecured, information on counterparty liquidity and credit risk becomes an important consideration in choosing trade partners. For the secured, TPR market, (Copeland et al., 2014) present suggestive evidence on the existence of stable relationship as part of their analysis on the bank run behavior in the TPR market during the recent financial crisis. However, due to data limitations, they don't measure directly the stability of the relationship, nor do they provide empirical evidence as to why these relationships exist or how they are structured.

We also extend the existing OTC literature to a new direction, namely that of relationship bundling, by examining the scope for broad relationships in the trading mechanism. Our evidence suggests that there are economies of scale in trading, which determine interactions across markets and shape overall needs for smooth funding or investment. We create an innovative dataset by combining TPR transactions data and MMFs regulatory reports in order to examine trading relationships both over time and across markets.

Finally, we provide an innovative approach to examine the role of relationships in mitigating liquidity shocks, namely using Treasury auctions as a quasi-natural experiment for TPR funding demand shocks and ON RRPs as funding supply shocks. Importantly, to the best of our knowledge, we also provide the first study on the effect of the Fed's RRP excercise on the TPR market.

The rest of the paper is organized as follows. Section 2 presents a short description of the triparty repo Market. Section 3 motivates our empirical hypotheses. Section 4 discusses our data, sample construction and the construction of the variables used in our regressions. Section 5 presents our empirical results. Section 6 concludes.

2 Trading Mechanism in the Triparty Repo Market

A repo is the sale of a security, or a portfolio of securities, combined with an agreement to repurchase at a pre-specified price on a specified future date. In the U.S., two types of repo transactions make up the broad repo market.[2] One is the bilateral, or "delivery versus payment (DvP)," market, where a repo is typically settled when the securities provider delivers the securities to, and simultaneously receives the cash from, the cash provider. The other type of repos is the TPR market, the focus of this paper, where two clearing banks facilitate the clearing and settlement of repo contracts on their own balance sheets, by maintaining cash and security accounts for investors (cash lenders) and dealers (cash borrowers).[3] Investors include institutional cash-rich investors, a large fraction of which (around 40 percent) are MMFs. Other investors include various asset managers, local or state government treasurers and securities lending agents. The dealers use the TPR market as a source to fund the collateral received by the investors in the bilateral market or their own securities inventories, such as their purchases in Treasury auctions.

Despite the existence of a clearing bank in the TPR transactions, trade agreements are essentially made bilaterally. The TPR clearing banks do not match dealers with cash investors, nor do they play the role of brokers in that market (Copeland et al., 2012). Instead, this bilateral trade mechanism entails search frictions, including the costs of pre-trade contracting, search, bargaining, and information asymmetry, all of which may give rise to the role of relationships. Specifically, first of all, before any actual transactions an investor and a dealer who wish to form a trade pair have to find and agree on some general trade framework. This takes the form of a contractual trading relationship by entering a "Master Repo Agreement" (MRA). Importantly, the MRA specifies, among other terms, repo haircuts—the difference between the market value of securities (collateral) and the cash loan amount—and the type of acceptable collateral. Although these terms may vary over time, they are not always negotiated on a daily basis, due in part to the cost of revising MRA.

Second, trade parties have to search for a matching partner. MMFs or dealers may sign an MRA with more than one counterparty. However, they may not, on each occasion, transact

[2] See Copeland et al. (2012) for an extensive description of the U.S. repo market.

[3] The General Collateral Finance market (GCF), a blind-brokered inter-dealer market, is also part of the tri-party market, as GCF repo settlement takes place through the tri-party repo platform. But GCF transactions are not included in our dataset and therefore don't enter our analysis.

with all the dealers they have contracted with. When it comes to trading, counterparties again need to search each other and negotiate on a set of additional, specific parameters. These include the maturity of the repo, the rate and cash loan amount (repo volume). The purpose of search is to elicit the best deal from existing MRA counterparties or to determine if it is worth to establish new MRA trading partners. Therefore, a search mechanism can take place for each individual trade.

Third, liquidity shocks may affect the search behavior even on the daily basis. Typically, dealers initiate the search early in the morning, with the large bulk of repo trades arranged before 10am. However, some deals may be amended later in the day, to accommodate intra-day liquidity shocks, such as investors' redemption for MMFs (Copeland et al., 2012). The bulk of trades would be confirmed by 3:30 pm, when settlement would start, with additional smaller batches settled continuously thereafter for later trades until 5:30.[4]

3 Hypotheses

In this section we motivate the hypotheses tested in our empirical analysis. Our first empirical goal is to examine the quantitative significance of trading relationships in the TPR market. In theory, the strength of trading relationships in a market may reflect the extent of search frictions (Ashcraft and Duffie, 2007). After all, in a frictionless, complete market where individual traders are price-takers, trade outcomes would not depend on the choice of trade partners. Duffie et al. (2005) and subsequent work, such as Afonso and Lagos (2015) who provide a formulation of the search-based model for the federal funds market, suggest that in the presence of search frictions, bilateral relationships are inherently strategic and reflect

[4]The completion of the settlement window would be at 5:15pm and by 6pm all cash-settlements would also be concluded. The timing for the trade matching and settlement has shifted earlier since 2010 as a result from the efforts of the Task Force on TPR Reform Payments Risk Committee (2012). When our sample starts, in September 2012, a significant part of the reforms had already been implemented. However, progress was made also through 2013 and continued into 2014 (Copeland and Selig, 2014; Payments Risk Committee, 2012).

each counterparty's alternatives to immediate trade.[5] In addition, network theory suggests that relationships can be generated endogenously in an unsecured OTC market, to reduce search frictions induced by information asymmetry (Babus and Hu, 2015).[6]

However, it is an interesting quantitative matter whether the search frictions discussed in the previous section may manifest in trading relationships in the TPR market. On one hand, being generally large, sophisticated, and well-known financial institutions, participants of the TPR market may have low marginal costs in locating a trade partner. Also, the use of high quality collateral may mitigate the concerns about asymmetric information on counterparty credit risk (Mills and Reed, 2008; Infante, 2015; Hu et al., 2015). On the other hand, various factors imply search frictions may still be significant. An important consideration is that collateral in the TPR market may provide a false sense of security. The seemly secured lending may unravel quickly during stress times, in part because MMFs, the major cash lenders in this market, are limited by regulations in their capacity to hold long-maturity securities. Thus, in the event of counterparty defaults, MMFs would have to sell quickly the collateral, sometimes at fire sale prices.[7] Under such conditions, MMFs may essentially treat repos as unsecured transactions, which in turn implies that the identity of the counterpart matters. These considerations, as well as the suggestive evidence by (Copeland et al., 2014), lead us to hypothesize that trade relationships exist in the TPR market.

We also hypothesize that the formation of trading relationship in the TPR market may depend on the broad interaction between the funds and dealers across markets. The relationship lending literature on banking has documented extensively that counterparts form stable

[5] Among others Duffie et al. (2007) treat the implications of search frictions for risky asset pricing; Vayanos and Weill (2008); Weill (2008) treat multiple assets in the economy; Lagos and Rocheteau (2009) introduce entry of dealers and a non-trivial choice of asset-holdings.

[6] Intermediaries in the model of Babus and Hu (2015) have the ability to enforce contracts and provide monitoring devices which sustain trade without collateral in cases where trade counterparties meet infrequently. Therefore, forming relationships in the OTC market reduces search and informational frictions and allows access to more favorable terms of trade.

[7] In distressed conditions, search frictions would increase and asset prices are undervalued, especially if additional trade partners would be needed (Antinolfi et al., 2015). Indeed, these dynamics explain why MMFs have completely withdrawn from the repo market in the wake of Lehman collapse (Copeland et al., 2014; Krishnamurthy et al., 2014).

relationships in order to achieve economies of scale in information collection and reduce information asymmetry (Petersen and Rajan, 1994; Ongena and Smith, 2000). Importantly, the scale economies in information can be achieved both by observing the borrower over time as well as over products (Petersen and Rajan, 1994; Boot, 2000). Indeed, the two main measures of relationship strength in this literature are the duration of the relationship and the scope of the relationship, the latter defined in terms of the different services offered by the bank and utilized by the firm (Ongena and Smith, 2000). In line with their predictions, we postulate that the formation of trading relationship in the TPR market may depend on the broad relationship between the investors and the dealers across markets, a strategy that could be motivated by informational gains or overall profit maximizing considerations.

Finally, we hypothesize that trading relationships facilitate the absorption of liquidity shocks for both sides of the TPR trade. While the banking literature often finds that relationship lending helps reduce asymmetric information concerns, empirical results on interbank lending tend to find relationships mitigating the impact of liquidity shocks (Ashcraft and Duffie, 2007; Afonso et al., 2014). The need of banks to cover their liquidity shortfalls or minimize surpluses results in relationship formation with banks with opposite liquidity needs. Unlike the federal funds market, participants in the TPR market are clearly delineated into borrowers and sellers. So by construction the TPR market also involves trades between counterparties with opposite liquidity needs. Even so, liquidity supply and demand can vary both over time and across agents, leading to a mismatch in the amount of needs of any fund-dealer pair. As in the federal funds market, this matching process involves search, transaction costs, and possible information asymmetry on either counterparty credit risk or liquidity shocks. Therefore, we postulate that trading relationships help mitigate liquidity shocks in the TPR market. Our innovation is that to identify the role of trading relationship, we explore quasi-nature experiments based on Treasury auctions and the Fed's ON RRPs exercises as proxies for shocks to the liquidity demand and supply, respectively.

4 Data, Sampling, and Variables of Interests

4.1 Data and Sampling

Our main dataset consists of all transactions in the U.S. TPR market, including those involving the Federal Reserve but excluding GCF ones, from September 2012 to April 2015. The sources of these transactions are confidential reports by the two clearing banks, the Bank of New York Mellon (BNYM) and J. P. Morgan Chase (JPMC). We sample transactions on one day each week throughout the period, when we have reports from both banks. Both banks reported the same set of fields, including the date of trade, the names of the investor and the dealer, repo quantity, rate, maturity, collateral type, and a flag for an open trade.[8]

We apply the following filters to construct our research sample. First, we restrict our analysis to transactions with overnight maturity (including open trades) and with Treasury as collateral. This restriction provides a more homogeneous sample and allows us to better identify the effect of trading relationships by reducing the influence of factors (such as collateral quality) for which we may not have sufficient information. On an average day, about 90 percent of the TPR trading volume concentrates on the overnight maturity, of which about 50 percent has Treasury as collateral. We also exclude quarter-ends from the analysis to limit seasonal effects on our results.[9]

Second, we focus on MMF investors only. We apply this restriction for two reasons. One, MMFs are a major investor in the TPR market (Hu et al., 2015; Krishnamurthy et al., 2014). Two, among the several main types of investors in this market, we can identify only MMFs with confidence and with sufficiently rich information about the investor characteristics, including fund family names for necessary aggregations.[10]

[8]These reported fields are the 13 minimum parameters required for TPR matching, as determined by the TPR Reform Task Force. Information on haircuts or specific CUSIPs of collateral is not among the required fields and is not included in these reports.

[9]Munyan (2015) documents the quarter-end seasonality in the TPR market. Specifically, European dealers tend to shrink their balance sheets at quarter-ends to reduce their asset basis used for leverage ratio calculations. Because we sample one day of observations each week, there are only three quarter-ends in our sample.

[10]The raw data contain names of investors and dealers but no unique identifier for them. To identify

Third, we include in our sample only the top dealers and MMFs ranked by total transaction volumes at the dealer-parent and the fund-family level, respectively. There are total 31 dealer parents and 73 fund families in our sample. For each month, we rank dealer parents and fund families based on their repo volumes over the previous month and keep the top 15 dealer parents and the top 40 fund families–a sampling approach similar to that by Ashcraft and Duffie (2007); Afonso et al. (2014). These top MMFs and dealers account for almost 99 percent of all transactions. So this filter is not restrictive at all, mainly removing those TPR participants with rather sparse activities.

For each fund family, we group its funds into two subfamilies according to whether a fund is an ON RRP-eligible counterparty. Eligible counterparties are those funds from whom the Federal Reserve is named as the borrowing dealer. We conduct our analysis at the dealer-parent and fund-subfamily (hereafter, "dealer" and "fund," respectively) level. In our sample, RRP eligible MMFs belong to 26 different families, all but two of which families also have funds that are not eligible. Within each sub-family, we aggregate the repo volumes on each day and calculate the average repo rate, weighted by the volume of each trade on that day.

Finally, we also combine information from a few other sources. Specifically, we use information in the Form N-MFP on repo and other assets holdings so as to construct measures for broader relationships (see details later). Also, we use data on RRP operations provided by the New York Fed to study the effect of RRP-induced liquidity shocks.[11] As shown in Figure 1, the key parameters of the RRP exercises, the individual cap and the RRP offer rate, have changed over time over our sample period– a variation that we will exploit in

MMFs, we first use string matching techniques to select investor names that contain MMF-related keywords (such as "money market mutual funds", "cash equivalent", and "liquidity fund"). We then cross-check our selection using the MMF names reported in the SEC Form N-MFP—a monthly filing by MMFs on their holdings of invididual securities at month-ends. Overall, we managed to identify almost 80 percent of the MMF's overnight Treasury repo volume reported in the SEC N-MFP data at month-ends.

[11] The ON RRP exercises started on 23 September 2013 to assess its effectiveness to set a soft floor on short-term interest rates, as part of the monetary policy normalization tools. The key policy parameters are the RRP offer rate, which is the highest overnight rate which the Fed is willing to pay on funds borrowed from RRP eligible counterparties, and the RRP Cap, which is the maximum amount of volume that each counterparty can lend.

our analysis (Frost et al., 2015). Furthermore, we use public data on Treasury Auctions, including aggregate allocated amount on Treasury Notes and Bonds.

4.2 Sample Statistics

Our final sample includes 21 unique parent dealers and 63 unique fund subfamilies, among whom there are about $25,000$ trades on the sample period, which is close to one-quarter of all the potential trades that would have occurred, should each fund transacted with every dealer on each day. (Recall that we aggregate all transactions between a dealer–fund pair on a given day and treat them as one trade.) On average, total daily trade volume is about \$150 billion. As shown in Table 1, the average trade has a volume of \$0.73 billion at a repo rate of seven basis points (bps).

We use transaction volumes of each dealer and each fund as a proxy for their relative sizes, following a methodology similar to Ashcraft and Duffie (2007). Specifically, denote the amount of repo trades between fund i and dealer d at time t by $V_{i,d,t}$, and the number of funds and dealers by N_f and N_d, respectively. Then, the size of a fund i at t, denoted $IV_{i,t}$, is defined as

$$IV_{i,t} = \sum_{s=t-1}^{t-c} \sum_{d=1}^{N_d} V_{i,d,s}, \tag{1}$$

where t is the current day of the month, $t-1$ is the previous day and $t-c$ is the same day of the previous calendar month. That is, we estimate the size of a fund using the total amount of repos lent by the MMF to all dealers over the previous "rolling month." For example, if today is Dec 30, the rolling month would be from Nov 30 until 29 Dec. Note that because we include only one trade date per week, a rolling month effectively consists on average of four days. Similarly, the size of a dealer d at t, denoted by $DV_{d,t}$, is estimated by the total repo dollar volumes borrowed by dealer d from all funds over the previous rolling month. That is,

$$DV_{d,t} = \sum_{s=t-1}^{t-c} \sum_{i=1}^{N_f} V_{i,d,s}. \tag{2}$$

Table 1 presents some statistics on size. On average, a fund lends about $16 billion of ON TPR, and a dealer borrows about $45 billion, over a month, reflecting relatively greater concentration of dealers in this market.

However, there is a large dispersion in both MMF and dealer sizes. For example, the monthly volume of the largest (1^{st}-ranked) MMFs has a mean of $45 billion and a standard deviation of $24 billion (with a range from less than $1 billion to as high as $90 billion). In stark contrast, the monthly volume of the smallest (40^{th}- ranked) MMFs has a mean of $0.25 billion and range from about $10 million to just under $1 billion. Similarly, for dealers, the largest (1^{st}-ranked) dealers record a total monthly TPR volume that ranges from $30 billion to over $670 billion, with a mean of $230 billion and a standard deviation of $180 billion. But the monthly volumes of the smallest (15^{th} ranked) dealers never exceed $10 billion.

4.3 Measuring Trading Relationships

In measuring trading relationships in the TPR market, we also follow a methodology similar to Ashcraft and Duffie (2007). From the MMF i's point of view, the strength of its relationship with dealer d is the dollar volume of repos that it lends to the dealer over the previous rolling month divided by its total amount of repo lending. In other words it measures the concentration of the MMF's lending to a specific dealer over a relatively-long period. The strength of a dealer's relationship with a fund is defined accordingly. To be precise, denote the fund-dealer and the dealer-fund relationship strength by $RS^i_{i,d,t}$ and $RS^d_{i,d,t}$, respectively. Then,

$$RS^i_{i,d,t} = \frac{\sum_{s=t-1}^{t-c} V_{i,d,s}}{IV_{i,t}}; \qquad RS^d_{i,d,t} = \frac{\sum_{s=t-1}^{t-c} V_{i,d,s}}{DV_{d,t}}. \tag{3}$$

By construction, these relationship strength measures range between zero and unity. The higher the value, the stronger the relationship.

We also define relationship formation variables as follows:

$$RF^{i}_{i,d,t} = \frac{V_{i,d,t}}{\sum_{d=1}^{N_d} V_{i,d,t}}; \qquad RF^{d}_{i,d,t} = \frac{V_{i,d,t}}{\sum_{i=1}^{N_f} V_{i,d,t}}. \tag{4}$$

That is, $RF^{i}_{i,d,t}$ is the fraction of fund i's total reverse repo volume at t that is lent to dealer d. In other words, it measures how the fund i distributes its current investments among the various dealers. So roughly speaking, $RF^{i}_{i,d,t}$ indicates whether a fund strengthens or weakens its existing relationship with a dealer. The same interpretation applies to $RF^{d}_{i,d,t}$.

Finally, we construct variables to proxy the trading relationships between an MMF and a dealer across in two broad sets of markets. The first one measures the relationship strength in other TPR markets, i.e. trading of repos outside the triparty overnight Treasury collateral space (in essense, this includes longer maturities and different types of collateral). We obtain the volumes of these repos using the Form N-MFP data as described above. The second one measures the relationship strength of MMFs and dealers using transactions of other money market claims between a fund and a dealer, including financial commercial paper, asset-backed commercial paper (ABCP), and certificates of deposits (CDs).[12]

For each of these two broad sectors, we follow a similar logic to define relationship strength. From the MMF i's point of view, the strength of its relationship in other repo markets with dealer d is the dollar volume of repos in other repo markets that it lends to the dealer over the previous rolling month divided by its total amount of repo lending in those other markets over the previous month. Similarly, the strength of MMF i's relationship in CP and CD markets with dealer d is the dollar volume of CP and CD that the MMF bought from a dealer over the previous rolling month divided by its total amount of CP and CD bought over the previous month. A similar logic applies for the dealer - investor relatioships. Recall that the Form N-MFP data are available for only month-ends. So we carry the same values over all trading days in the previous month.

[12] We treat the program sponsors as “the issuer” in the ABCP conduits.

5 Results

In this section, we first present the results from a descriptive analysis on the strength and formation of trading relationships in the TPR market, followed by an analysis on the determinants of relationship formation. We then examine the value of trading relationships from three different angles: the effects of relationships on the likelihood of a trade and terms of trade, the role of relationships in buffering shocks to the supply of funds due to the Fed's RRP exercises and shocks to the demands for funds due to Treasury auctions.

5.1 Descriptive Evidence on Trading Relationship

We have learned from the preivous section that out of all possible trade pairs between funds and dealers in our sample, only around a quarter execute actual trades. Table 2 provides additional characteristics on these trades from the point of view of relationship strength and formation.

A few points are worth noting. First, trades have occurred among a small set, but a similar fraction, of funds and dealers, in terms of both relationship formation and relationship strength in the TPR market under investigation and broader markets. On average, a given fund lends to just over a quarter, or about four, of the potential borrowers over a month; similarly, a given dealer borrows from a touch shy of a quarter, or about sixteen funds (in terms of sub-fund families), of the potential lenders. This can be deducted by the percent of non-trades for RS MMF and RS Dealer measures (column $Var. = 0$), as well as from the means of RS MMF and RS Dealer in cases of actual trades. Looking at the respective columns for the RF variable, on a daily basis trades have occurred among roughly one fifth (or thirteen and three, respectively) of both funds and dealers. Thus, while relationships tend to be relatively concentrated among a small set of trade partners, there are nonetheless some rotations of both lending and borrowing partners within a month.

Second, the number of dealers with whom a fund has trading relationship is increasing in the fund's size, and the same holds for dealers. Specifically, on average, the largest fund (ranked 1 by size) has had trading relationship with about half (or eight) of potential borrowing dealers over a month, while the smallest fund (ranked 40 by size) with only one tenth (or about two) of potential dealers (see column $Var. = 0$). Similarly, the largest dealer has had trading relationships with about 43 percent (or 35) of funds over a month, while the smallest dealer with six percent (or four) of the funds. The same pattern holds in terms of relationship formation as well, only with smaller magnitudes. These findings suggest that trading relationships appear more concentrated for the smaller dealers and much more so for the smaller investors.

To see further how relationship strength varies with size, we plot in Figure 2 the average relationship strength variables by the size ranking of the dealers and investors. As shown, the relationship strength for both funds and dealers is decreasing with their respective sizes. This finding is consistent with Copeland et al. (2014), who find from more aggregate data that smaller dealers (investors) tend to form more concentrated relationships (that is, they borrow (lend) from fewer investors (dealers)). It is also similar to the interbank results of Furfine (1999); Afonso et al. (2014), who find that small banks choose to form more concentrated lending relationships than large banks.

Third, conditional on having trading relationships, both relationship strength and formation are not exclusive but fairly concentrated, and further, smaller funds and dealers tend to have more concentrated relationships. The conditional average strength values for both funds and dealers are all far below one, suggesting that the relationships among trading partners are not exclusive. Specifically, Table 2 suggests that MMFs tend to lend on average only twenty-six percent of their total volumes to a specific dealer over a month, and for dealers the number is even lower, under ten percent. However, the medians of respective variables are all smaller than their means, suggesting that relationship strength is skewed to the right, which speaks to a fair amount of concentration in relationships. The same pattern holds for relationship formation as well as for the broader relationship strength variables (in other repo markets and in CP and CD markets).

Finally, we find that both funds and dealers, but more so for funds, form concentrated, stable relationships with a small subset of trade partners. To see this, we estimate cumulative relationship strength measures using all transactions over the entire sample period, which we call Long-Term Relationship Strength (LTRS), and plot the distribution in Figure 3. Essentailly, LTRS is calculated using the same formula as RS, except that both denominator and numerator are aggregated across the whole sample, and not across the previous months. We do this in order to caputre the strenth of "life-long" and therefore stable relationships. To illustrate, for example, the first bar in Panel A shows the distribution of all dealers cumulative LTRS with their top-ranked investor, the second bar shows the distribution of all dealers LTRS for the top 1 and top 2 investors, and so on. A similar logic holds for Panel B.

The figures suggest that both dealers and investors have traded with a number of partners over the sample period. However, as shown in Panel A, a typical dealer (in terms of median) obtains close to 40 percent of their funds from its top "life-long" lending fund, and just short of 60 percent from its top two funds. Interactions with its top five funds provide almost 80 percent of their funds. As shown in Panel B, a typical fund (again in terms of median) invests 60 percent of its funds to its top borrowing dealer, whereas the top two dealers provide more than 80 percent of its lending. Because the relationships and ranking are estimated using the entire sample period, the concentrations also suggest that these relationships are stable over time. In our analysis below, we will give additional qualifications on the stability of relationship and its value to absorb liquidity shocks.

5.2 The Determinants of Relationship Formation

We now examine the determinants of relationship formation. We have found above that, consistent with finding in previous literature on interbank markets, larger funds and dealers trade with a greater set of counterparties but that their trading relationships tend to be concentrated and stable over time with a small set of trade partners. Thus, we hypothesize that relationship formation is positively related to fund and dealer sizes and the strength of existing relationships. Moreover, we have already hypothesized that relationship formation in the overnight Treasury TPR trading may depend on relationships in broad markets that the parties interact with.

Our empirical method is the following. As we discussed earlier, on any given t, we first form potential trade pairs between all dealers and sub-fund families in our sample [13]. Then, we adopt a Tobit approach to estimate the following empirical models:

$$Y_{i,d,t} = f\left(\mathrm{IV}_{i,t}, \mathrm{DV}_{d,t}; \mathrm{RS}^{i}_{i,d,t}, \mathrm{RS}^{d}_{i,d,t}; \text{Broad relationship}; \text{Fixed effects}\right) + \epsilon_{i,d,t}, \quad (5)$$

where $Y_{i,d,t}$ is either $\mathrm{RF}^{i}_{i,d,t}$ or $\mathrm{RF}^{d}_{i,d,t}$, which is censored at zero. As noted in Section 4.3, IV and DV are proxies for the sizes of MMFs and dealers, respectively, and RS^i and RS^d are the relevant relationship strength variables, accounting for the existing relationships, while "broad relationship" variables are relationship strengths in both other repo trades and the CP and CD markets between each pair. Finally, we use fixed effect variables to control for unobservable heterogeneity at the dealer parent, fund family, and macroeconomic levels.

The regression results are presented in Table 3. As shown, we start with a benchmark estimation by excluding broad relationship variables, which allows us to utilize the whole sample. We then estimate the full specifications, which use just over an half of the whole sample due to many missing values among the broad relationship variables. To check the robustness of our benchmark results to this large sample change, we rerun the benchmark regression on the restrictive sample.

A few findings are worth noting. First, as we expected, the likelihood of relationship formation for investors increases with investor sizes. All regressions of $RF^{i}_{i,d,t}$ show a positive,

[13] To this end, we pair up all funds (at the sub-family level) and dealers (parents) to form the sample of potential trades. For example, there could be (at most) $15 * 80 = 1200$ potential trades on a given day if all top 40 MMF families identified in that month have both RRP-eligible counterparty funds and ineligible funds (so each family has two sub-families). In our day, the number of potential trades varies each month, based on whether the top MMF families identified for this month have eligible and/or non-eligible funds.

statistically significant coefficient for $\mathrm{IV}^i_{i,d,t}$. Thus, all else being equal, larger funds tend to be inclined to form a relationship with any given dealer. The converse for dealers doesn't hold, however, as all coefficients of $\mathrm{DV}^d_{i,d,t}$ of $\mathrm{RF}^d_{i,d,t}$ regressions are not statistically significant.

Second, for both investors and dealers, relationship formations in the overnight Treasury TPR trades depends strongly and positively on their existing relationship strength, slightly more so for investors. All coefficients, whether in benchmark or in full specifications, of $\mathrm{RS}^i_{i,d,t}$ and $\mathrm{RS}^d_{i,d,t}$ in regressions of $\mathrm{RF}^i_{i,d,t}$ and $\mathrm{RF}^d_{i,d,t}$, respectively, are close to one and statistically significant, with those of investors being slightly greater. These results confirm that relationships reinforce over time and thus are stable.

Third, for investors, relationship formation in the overnight Treasury TPR market depends positively on their broad market relationship strengths with a given dealer, while the opposite holds for dealers. In the $\mathrm{RF}^i_{i,d,t}$ regression, the coefficents of $\mathrm{RS}^i_{i,d,t}$ for both other repos and CP/CDs are all positive and statistically significant, but the magnitudes are much smaller than their dependence on the overnight Treasury TPR trades. Thus, an average investor tends to allocate larger fractions of their funds to dealers with whom the investor has relatively stronger relationships also in other markets. This may suggest that MMFs "learn" about their dealers in multiple markets. Interestingly, for dealers, the regression of $\mathrm{RF}^d_{i,d,t}$ produces negative and statistically signficant coefficients of $\mathrm{RS}^d_{i,d,t}$ for both other repos and CP/CDs. So, it seems that dealers who tend to fund relatively more in other (repo and CP/CD) markets from specific investors, have less recourse to these investors in the ON Treasury TPR market. In other words, dealers tend to allocate a smaller fraction of their borrowing to those investors who account for a relatively larger fraction of the dealers' funds in markets outside of the overnight Treasury TPR trades.

5.3 The Value of Relationships

We are now turning to analyze the value of relationships in the TPR market. Our approach is to study first how relationships may affect the likelihood of a successful trade and the terms of trade and then how relationships may help absorb shocks to both demand for and supply of funds. This analysis sheds light on why relationships exist in this market, despite the fact that the claims traded are secured with high quality collateral.

5.3.1 The Effects of Relationships on Trading

We hypothesize that relationships may affect terms of trade among counterparts, such as the availability of credit and the price of the loan (Elyasiani and Goldberg, 2004; Ashcraft and Duffie, 2007; Afonso et al., 2014). Specifically, we analyze how relationships affect volumes and rates in the repo market, as well as the probability of a trade occurring. We adopt the following regression specification:

$$Y_{i,d,t} = f\left(\text{IV}_{i,t}, \text{DV}_{d,t}; \text{RS}^{i}_{i,d,t}, \text{RS}^{d}_{i,d,t}; \text{Fixed effects}\right) + \epsilon_{i,d,t}, \tag{6}$$

where $Y_{i,d,t}$ is a placeholder for three different dependent variables: the probability of trade (a dummy variable which takes the value of one when a trade occurs and zero otherwise), trade volume, and the associated repo rate. The definitions of the independent variables are the same as in (5).

We use a probit model to estimate the likelihood of a successful trade among all potential tradable pairs between investors and dealers. As discussed earlier, on any given t, we first form potential trade pairs between all dealers and sub-fund families in our sample. For each pair, the dependent variable equals to 1 if a trade occurs, 0 otherwise. We use OLS regressions for trade volume and repo rates, conditional that a trade occurs.

As shown in Table 4, the results support the view that relationships matter for the TPR trades. Most coefficients are statistically significant at standard significance levels. As we can see in the first column, the stronger the relationship strength, the larger the probability of a trade. This result is consistent with our earlier finding of stable relationships over time. We also find that trade volumes increase with relationship strength for both investors and dealers, conditional on having a trade. Interestingly, for repo rates, we find that a greater relationship strength leads to less bargaining power over the rate, as the MMFs with higher dependence on a given dealer may accept a marginally lower rate on their investment, while dealers with higher dependence on MMFs may need to pay higher funding costs.

The size effects are also worth noting. Consistent with our relationship formation resutls, the likelihood of successful trades is increasing in both investor and dealer sizes. Also, conditional on a trade, trade volumes are increasing in sizes. In terms of repo rates, they don't depend on investor size but depend negatively on dealer size.

5.3.2 The Fed's RRP Tests as Shocks to the Supply of Funds

How do relationships affect the terms of trade when liquidity shocks occur? Evidence from the studies on the interbank loan market suggests that relationships can buffer such shocks (Ashcraft and Duffie, 2007; Afonso et al., 2014). Here we first use the Fed's RRP as a quasi-experiment to study whether relationships may help buffer shocks to the supply of funds towards the broker-dealers. By borrowing from a set of TPR market participants, the Fed's RRP operations drain the funds that could otherwise be lent to broker-dealers. Thus, these operations effectively induce a negative shock to the supply of funds for dealers who typically borrow in the TPR market.

We estimate how the RRP operations affect the likelihood of trades as well as the terms of trades conditional on a trade has occurred. Our approach is to first use a difference-in-differences (DID) method to analyze the effects of the RRP operations, and then to examine how these effects may vary with relationship strength. To the best of our knowledge, this is the first study on the impact of RRP on the TPR market.

We employ the following specification to estimate the RRP effects:

$$Y_{i,d,t} = f\left(\text{RRP}; \text{IV}_{i,t}, \text{DV}_{d,t}; \text{RS}^{i}_{i,d,t}, \text{RS}^{d}_{i,d,t}; \text{Fixed effects}\right) + \epsilon_{i,d,t}, \tag{7}$$

where "RRP" contains the difference-in-difference policy variables. We examine two different models for "RRP." In the first model, "RRP" includes dummies "Eligible"—a dummy taking the value of unity if the MMF sub-family is an eligible counterpart to ON RRP and zero otherwise), "After"—a dummy taking the value of unity after the introduction of ON RRP and zero before that, and the interaction between the two dummy variables—the DID term. The coefficient of the DID term tells us the impact of the policy on the treatment group—the MMFs who are counterparties of the ON RRP tests. To see why, note that the first difference compares the outcomes in the private repo market before and after the RRP tests began. Given that in the period following the RRP tests there may be factors other than the RRP tests that have affected the markets, such as regulatory changes, variables that are unobservable to the researcher. To control for these unobservables, the second difference compares the changes of trade terms related to counterparties, which are directly affected by RRP, to those of non-counterparties, which are not directly affected by RRP. These second differences would identify the net effect of the RRP tests on counterparties.

In the second model, we exploit the variation in the individual caps and offer rates to estimate the intensive marginal effect of the RRP tests. That is, "RRP" contains the "Cap" and "Spread"—equal to RRP offer rate minus GCF repo rate, together with dummy variables "Eligible" and "After" and all necessary interaction terms. We use "Spread" as a proxy of the relative attractiveness of the RRP rate, as the GCF rate approximates the cost of repo funding for the dealers and historically tends to move in line with other short-term money market rates. The RRP trades become more attractive for MMFs compared to alternative markets if the RRP offer rate increases compared to the money market rate. Our key variables of interest are the triple interaction terms Eligible $\times$ After $\times$ Cap and Eligible $\times$ After $\times$ Spread, for their coefficients tell us the impact of the changes in policy parameters on the treatment group (the RRP counterparts) after the RRP started. Other independent variables are the same as in (6).

The results of the above two models are presented in two panels in Table 5. As shown in Panel A, after the RRP, the eligible counterparties to the Fed were less likely to enter a private repo trade; and in case they did, they would transact at lower volumes and a marginally higher rate. These results are statistically significant. They imply that, first, the RRP appeared to have led an overall decline in private repo volumes over time, over and above any market observed trends, and that, second, this decline came from both changing the relationship structures between MMFs and dealers as well as the volumes. In other words, on aggregate, it appears that following the RRP, MMFs replaced repos with dealers with the Fed, and had lower volumes in the remaining repos they conducted. However, this shift likely offered a competitive edge for MMFs in negotiating rates in the private repo market, as the counterparty MMFs managed to get marginally higher repo rates.

The results shown in Panel B again confirm that following the introduction of the the RRP the probability of a trade was lower and, given that a trade occurred, the volume was lower and the rate was higher for counterparty MMFs. Higher caps and spreads further reinforced this outcome. Namely, as individual caps rose and as the RRP offer rate increases vis-a-vis the GCF rate, counterparties preferred to switch their lending away from the market and into the Fed, therefore lowering the probability of a trade in the private repo market. In case that a trade occurred, it would be at a lower volume and a higher rate. Overall, results suggest an eagerness of market participants to participate in the Fed operations and lend to the Fed instead of private dealers.

We have established that the RRP significantly changed terms of trade in the TPR market. We want to know how counterparts with stronger relations reacted to the RRP impact. In other words, does the impact of RRP to the private repo market change for MMFs depending on their dependence patterns? Do relationship characteristics affect the impact of RRP? In order to answer this question, we interact the MMF relationship strength with the policy parameters.

The specification again builds upon the first model of (7) by including interactive terms between MMF relationship strength and "RRP" variables (that is, "Eligible" and "After").

The coefficients of these triple interaction term Eligible × After × $\text{RS}^{i}_{i,d,t}$, measure how the impact of RRP on repo trading may depend on relationship strength of the funds with their borrowing dealers.

The results are shown in Table 6. As we can see, following the RRP, eligible MMFs with higher dependence on dealers were less likely to shift towards the Fed and still maintained trades with higher overall volume (the addition of the two relevant interaction terms for the volume equation is positive), at marginally higher rates. These results suggest that MMFs with high dependency maintain their relationships relatively more and are remunerated for this by getting higher rates. Therefore, relationships can help to buffer liquidity shocks coming from the introduction of the RRP.

5.3.3 Treasury Auctions as Shocks to the Demand for Funds

We now use Treasury auctions as a laboratory to investigate the effect of stronger relationships in buffering shocks to dealers' demand for TPR funding—shocks that are caused by exogenous variations in Treasury auction amounts. The premise of our analysis is that the TPR market is a major funding source for securities dealers, who often use it to finance their purchase of Treasury collateral. We postulate that stronger relationships may facilitate funding for dealers, especially on days of exogenous shocks in the supply of Treasury collateral.

In order to test this hypothesis we begin by estimating a proxy for the liquidity shocks in Treasury auctions.[14] The idea is to simply remove observable patterns in the data, given the different types of collateral and maturities involved in these auctions. To do that, we regress the total allocated volume in each Treasury auctions on fixed effects for the maturity and the type of securities and lagged volumes (to take into account of the refinancing of past debt). We recognize that seasonality patterns are also important in determining the outcome of auctions, and we deal with them in a follow-up step in our analysis, in the context of our

[14] We also ran these estimations using the actual allocated volumes in the Treasury Auctions instead of the residuals, and the results are qualitatively the same.

model to assess the impact of relationships, which includes time fixed effects (see below). We add up the residuals (by security type and maturity) per day and thus construct a daily Treasury auction liquidity shock series.

We then adopt the already familiar methodology in order to assess the impact of relationships on liquidity shocks. The model specification relies on the following equation:

$$Y_{i,d,t} = f\left(\text{Tr. auction}; \text{IV}_{i,t}, \text{DV}_{d,t}; \text{RS}^{i}_{i,d,t}, \text{RS}^{d}_{i,d,t}; \text{Fixed effects}\right) + \epsilon_{i,d,t}, \tag{8}$$

where “Tr. Auction” includes the Treasury action shock series, as derived above, as well as the interaction between this series and the dealers’ relationship strength with their lenders. The coefficients of the interaction terms, the DID effect, tell us how the impact of a positive shock to the dealer’s demand for liquidity may depend on the strength of the dealer’s relationship with its lenders. Other independent variables are the same as in (6).

The results are presented in Table 7. As we can see, stronger relationships lead to better funding ability of dealers for a given positive liquidity shock. Positive liquidity shocks lead to larger TPR volumes and rates. These results may be due to two reasons. First, dealers have to compete for funds more aggressively when the Treasury borrows a lot, driving up repo rates and volumes. Second, dealers need to finance their auction awards, which also puts upward pressure on rates and volumes. However, the probability of finding a match declines, although this results is not statistically significant.

How does having stronger relationships affect these results? On days of positive shocks in Treasury issuance, dealers who have stronger relationships with investors are more likely to trade with them, and in general dealers can achieve larger volumes (positive coefficient on Tr. auction $\times$ RS Dealer in the Volume equation) and lower rates (the coefficient of Tr. auction $\times$ RS Dealer on Rate equation is negative), compared to dealers who have weaker relationship with their trade partners.

6 Conclusion

This paper empirically analyzes the formation and the role of relationships in the TPR market, an OTC, secured, funding market. Previous theoretical and empirical literature in unsecured OTC markets, found that relationships helped to reduce search frictions, as stable partnerships can be formed among counterparts with opposite liquidity needs, a process which would lead to an increased tolerance against liquidity shocks. Search frictions could also be mitigated by economies of scale in information creation, which typically help to reduce informational asymmetries. Would the same considerations extend to the TPR market?

The unique features of the TPR market beg for quantitative analysis on the importance of trading relationship, as a direct application of previous literature results may not be obvious. On the one hand, the TPR market is a secured market, and so arguably, the existence of collateral could attenuate informational asymmetries. On the other hand, search frictions do exist in the TPR market, as the clearing banks only settle obligations and do not take part in the matchmaking process. Therefore, trade counterparts need to search and find each other. Moreover, by definition, trade counterparts in the TPR market have opposite liquidity needs: Investors offer cash and dealers borrow it. The TPR market is a funding market for dealers and therefore the role of relationships in alleviating liquidity and funding shocks should be important. Finally, participants in the TPR market transact in a number of different markets, allowing for the role of economies of scale in broader trading relationships.

We provide empirical evidence on the existence and importance of relationships in the TPR market. We find that participants in the TPR markets interact with a relatively broad number of counterparts and form stable and strong relationships with a subset of them. Larger players tend to concentrate relatively more on fewer relationships, and these players tend to cater these relationships in a number of different markets. Smaller players tend to form more localized relationships in the TPR market.

Indeed, an important finding relates exactly to the scope of relationships observed in the TPR market. Our analysis leads us to conclude that relationships in this market between investors (MMFs in this paper) and dealers are formed as part of a broader relationship nexus across markets. We find that the existence of past relationships in other markets is positively correlated with the existence of relationships in the TPR market. This suggests that, when forming relationships, counterparts tend to maximize synergies from these relationships across markets. In this sense, the identity of the counterpart matters for reasons that possibly incorporate the credit quality of the counterparty.

Finally, we find that, once formed, relationships can protect counterparts against liquidity shocks. We analyze two shocks specific to the TPR market. One is the Fed RRP operations, which could be seen as a negative funding shock for the dealers. We provide evidence that the RRP changed the structure of the market by severing relationships between counterparts and therefore reducing the possibility of private repo trades. Once these trades occur, the volume would be lower and the rate a bit higher, suggesting that the RRP increased the bargaining power of MMFs. These results would be stronger when the RRP parameters would change in a direction that would make the RRP more attractive to MMFs. However, stronger relationships can help to mitigate negative shocks on the probability and volumes of trades, whereas they enhance further the bargaining power of MMFs. Another liquidity shock considered is the Treasury auctions, which can be seen as a positive funding shock for the dealers. Again we find a positive impact of relationships on the ability of dealers to fund. Namely, dealers who have stronger relationships with investors are more likely to trade on Treasury auction days and in general can achieve larger volumes and lower rates compared to dealers with more dispersed counterparties.

Overall, this paper adds to the literature on OTC relationships in a number of ways. First, the paper clarifies why previous OTC literature results should be applied with caution in a secured market, and provides evidence of the role of relationships using a novel dataset. Moreover, it highlights that the process of relationship formation in the TPR market should be seen in the context of relationship formation across different markets, as broader synergies maybe motivating the choice of a counterpart. Finally, this paper analyzes for the first time the impact of the RRP operations in the TPR market and how relationships have affected this impact, providing an importance context for policy makers to analyze the effectiveness of Fed measures.

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Figure 1: **The Parameters of the Fed's ON RRP Tests**

This figure shows the time series of the parameters of the Fed's overnight reverse repo (ON RRP) tests, including the ON RRP offer rates and the individual caps.

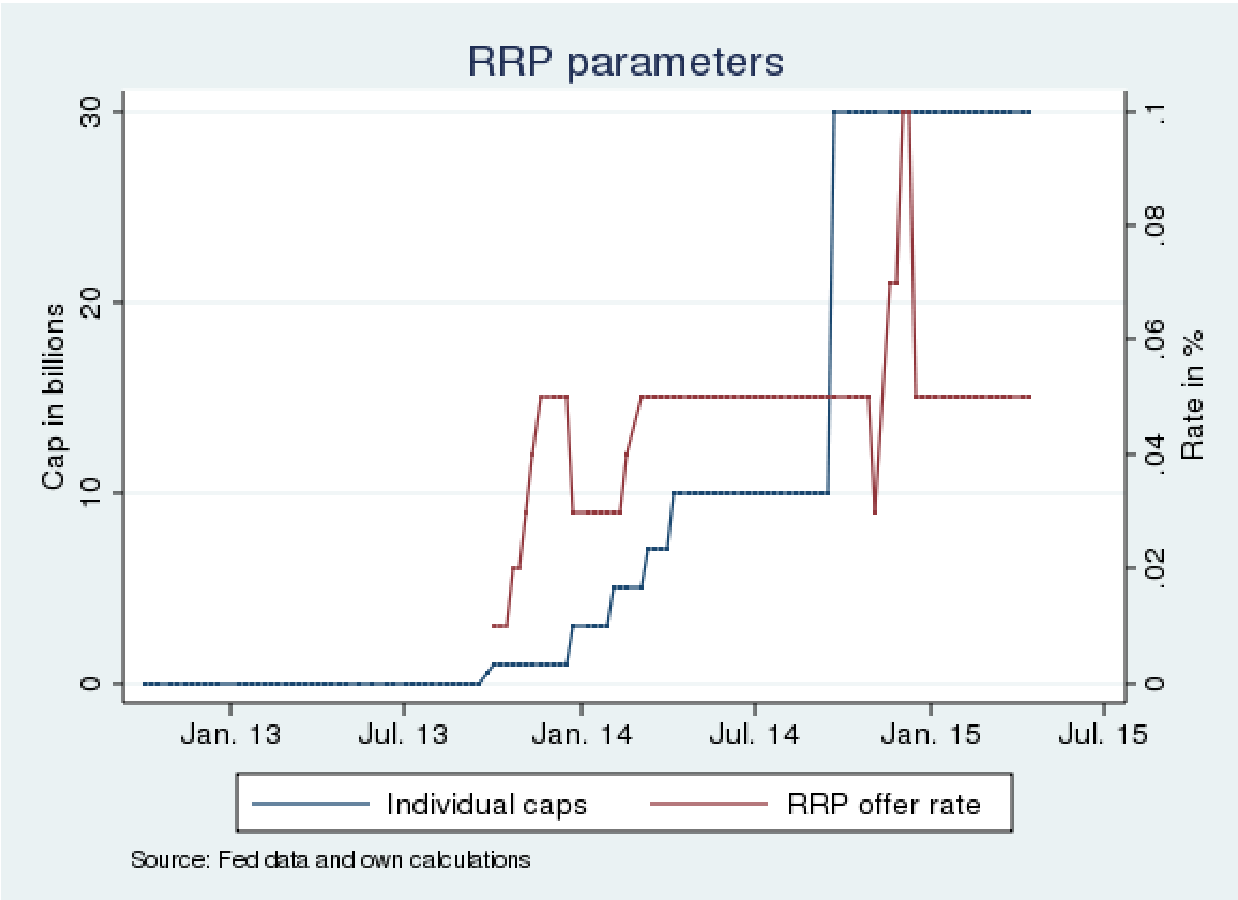

Figure 2: **Average Relationship Strength by Investor and Dealer Sizes**

This figure plots the average relationship strength (RS) measures for the top 40 investors and the top 15 dealers. RS is averaged for each investor or dealer rank over time.

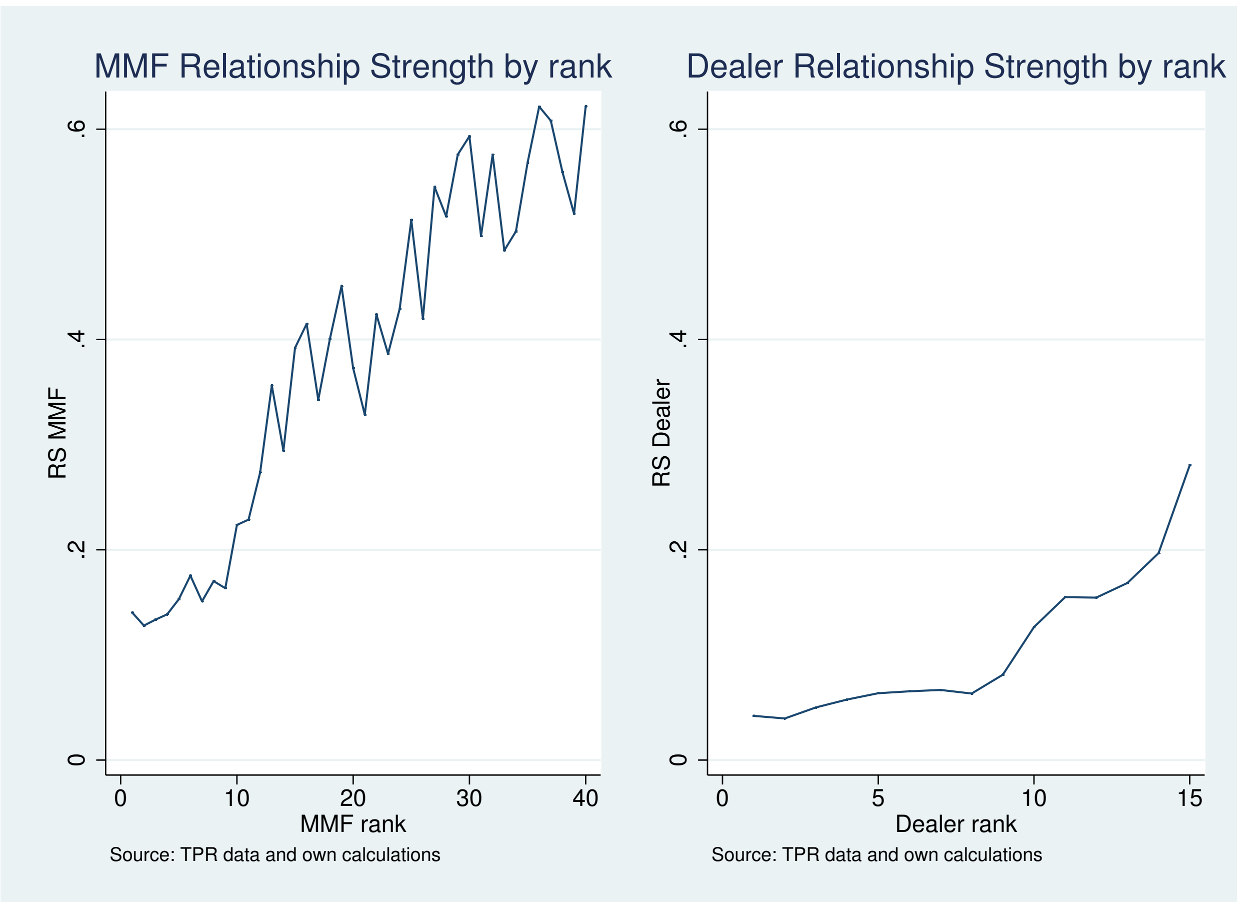

Figure 3: **Distribution of Long-Term Relationship Strength**

The figures plot the distribution of long-term relationship strength (LTRS) for dealers (Panel A) and investors (Panel B). Long-term RS is calculated using the same formula as (3) except that both denominator and numerator are aggregated over the entire sample. That is, they represent volumes that each dealer, Panel A, (investor, Panel B) borrows (lends) from her investors (dealers) over the whole sample, as a percent of her total volume borrowed (lent). We then accumulate LTRS over the rank of the counterparties, from the investor (dealer) with whom a dealer has greatest LTRS to the smallest. The boxplots show the distribution of LTRS of dealers (Panel A) and investors (Panel B), respectively, by such ranking.

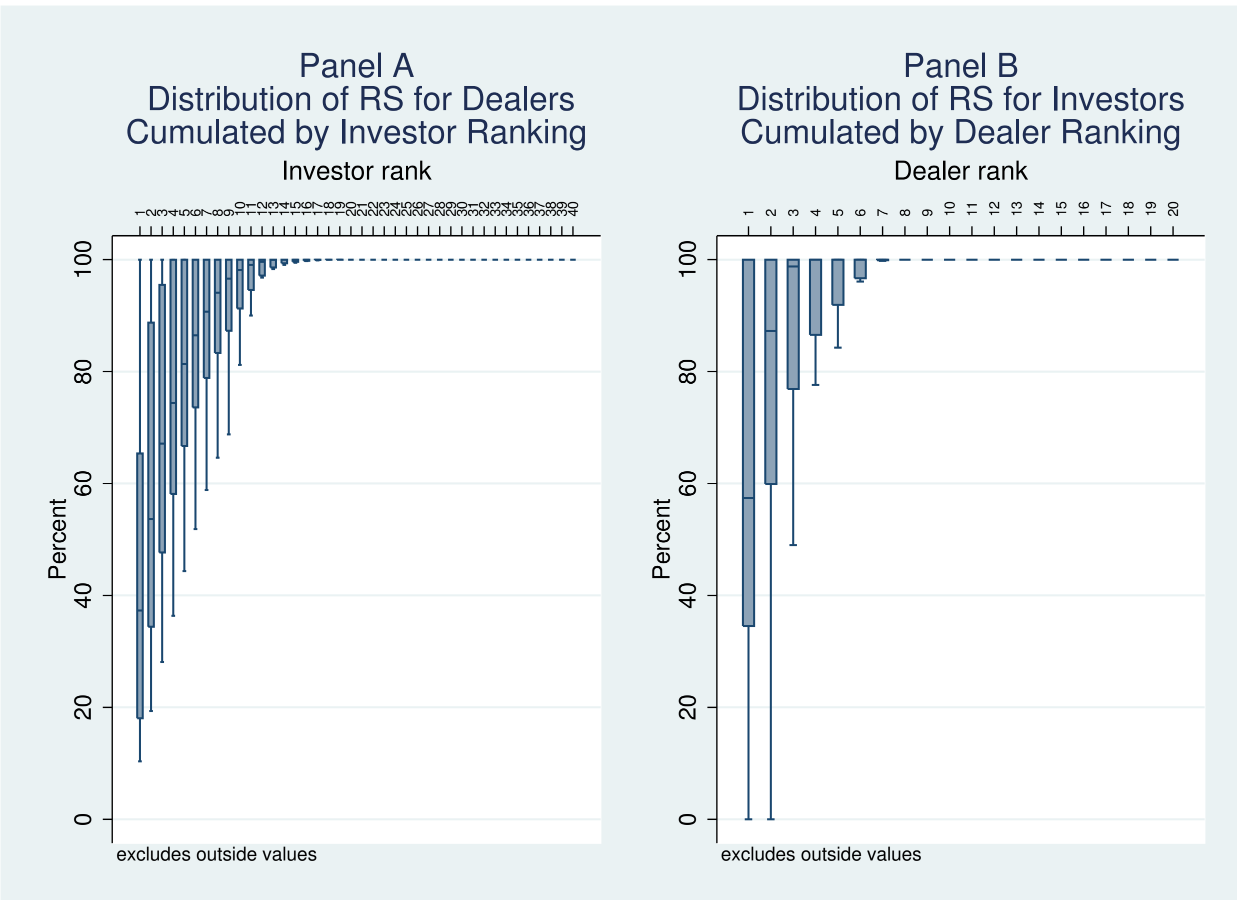

Table 1: **Sample Statistics**

This table describes our sample. Summary statistics are estimated using transaction information on actual trades aggregated at the sub-fund family and dealer parent level. "Trade volume" is transaction amount in billions of dollars. "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2).

Var.	Mean	Median	St. Dev	Min	Max
Trade Volume	0.73	0.25	1.79	0.00	27.70
IV	15.98	9.70	17.86	0.00	90.34
Rank 1	44.82	46.18	23.34	0.00	87.13
Rank 40	0.25	0.22	0.16	0.00	0.96
DV	45.27	24.88	82.54	0.00	673.18
Rank 1	185.31	63.45	173.06	28.65	673.18
Rank 15	2.54	1.93	2.18	0.00	8.38
TPR rate	6.77	5.00	4.88	0.00	35.00
GCF rate	0.11	0.10	0.06	0.02	0.30
RRP offer rate	0.03	0.05	0.02	0.00	0.10
N	24812				

SOURCE: Federal Reserve Bank of New York and authors' calculations.

Table 2: **Relationship Statistics**

This table presents descriptive statistics of the relationship variables. The first column, denoted Var. = 0, presents the percent of observations where each respective variable equals to zero in the sample with all possible interactions between MMFs and dealers. The columns under Var. > 0 show statistics conditional on each respective variable is greater than zero. "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). "RF MMF" and "RF Dealer" are relationship formation variables as in (4). The "RS MMF–CP/CDs" and "RS MMF–Other repos" are RS measures for MMFs in the CP/CDs trades and repos other than overnight Treasury TPR trades, respectively; while "RS Dealer–CP/CDs" and "RS Dealer–Other repos" for dealers. See details in Section 4.3. Note that the minimum values that appear zeros are due to rounding.

	Var.=0	Var.>0				
Var.	Percent	Mean	Median	St. Dev	Min	Max
RS MMF	74.03	0.26	0.14	0.29	0.00	1.00
Rank 1	50.94	0.14	0.08	0.21	0.00	1.00
Rank 40	89.33	0.63	0.57	0.34	0.01	1.00
RS Dealer	76.49	0.07	0.04	0.12	0.00	1.00
Rank 1	57.48	0.04	0.03	0.04	0.00	0.36
Rank 15	93.93	0.28	0.20	0.24	0.00	1.00
RF MMF	79.48	0.28	0.16	0.29	0.00	1.00
Rank 1	62.13	0.14	0.08	0.21	0.00	1.00
Rank 40	91.85	0.64	0.59	0.33	0.01	1.00
RF Dealer	79.29	0.08	0.04	0.13	0.00	1.00
Rank 1	61.26	0.04	0.03	0.05	0.00	1.00
Rank 15	94.5	0.31	0.24	0.26	0.00	1.00
RS MMF - CP and CD	59.65	0.16	0.12	0.15	0.00	1.00
Rank 1	40.48	0.11	0.10	0.08	0.00	1.00
Rank 15	64.18	0.18	0.15	0.16	0.01	0.97
RS Dealer - CP and CD	65.19	0.05	0.01	0.09	0.00	0.99
Rank 1	75.16	0.07	0.02	0.09	0.00	0.48
Rank 15	66.91	0.05	0.01	0.11	0.00	0.99
RS MMF - Other repo	65.17	0.18	0.12	0.20	0.00	1.00
Rank 1	38.8	0.11	0.08	0.11	0.00	0.89
Rank 15	82.70	0.36	0.29	0.24	0.04	1.00
RS Dealer - Other repo	69.58	0.06	0.02	0.08	0.00	0.68
Rank 1	48.2	0.03	0.01	0.05	0.00	0.37
Rank 15	75.34	0.07	0.03	0.10	0.00	0.67

Table 3: **Determinants of Relationship Formation**

This table presents results of Tobit regressions estimating the determinants of relationship formation. The dependent variables, "RF MMF" and "RF Dealer," are relationship formation variables as defined in (4). The independent variables are defined as follows: "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2). "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). The "RS MMF–CP/CDs" and "RS MMF–Other repos" are RS measures for MMFs in the CP/CDs trades and repos other than overnight Treasury TPR trades, respectively; while "RS Dealer–CP/CDs" and "RS Dealer–Other repos" for dealers. All regressions include fixed effects to control for unobervable heterogeneity at the fund family, dealer parent, and macroeconomic levels. Heteroskedasticity-robust p-values are shown in parentheses. *, **, and ***, denotes the 10, 5, and 1 percent significance levels.

	Whole sample		Partial sample		Partial sample	
Indp. Var.	RF MMF	RF Dealer	RF MMF	RF Dealer	RF MMF	RF Dealer
IV	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
DV	-0.000**	-0.000	-0.000**	-0.000	-0.000	-0.000
	(0.036)	(0.220)	(0.029)	(0.355)	(0.150)	(0.680)
RS MMF	1.265***	0.144***	1.234***	0.156***	1.128***	0.120***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RS Dealer	0.345***	1.087***	0.304***	1.075***	0.310***	1.072***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RS MMF - CP and CD					0.068***	0.031***
					(0.000)	(0.000)
RS Dealer - CP and CD					-0.117***	-0.066***
					(0.000)	(0.000)
RS MMF - Other Repo					0.179***	0.066***
					(0.000)	(0.000)
RS Dealer - Other Repo					-0.098***	-0.024***
					(0.000)	(0.008)
N	82,944	87,907	41,929	44,592	41,929	44,592

Table 4: **The Effects of Relationships on Triparty Repo Trading**

This table presents results of regressions estimating the effects of relationship strength on the probability of a trade over all potential trading pairs between funds and dealers, and conditional on having a trade, on trade volumes and repo rates. The independent variables are defined as follows: "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2). "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). All regressions include fixed effects to control for unobervable heterogeneity at the fund family, dealer parent, and macroeconomic levels. Heteroskedasticity-robust p-values are shown in parentheses. *, **, and ***, denotes the 10, 5, and 1 percent significance levels. Rate and spreads are measured in percentage points.

Indp. Var.	Pr(trade)	Volume	Rate
RS MMF	5.330***	0.577***	-0.279***
	(0.000)	(0.000)	(0.000)
RS Dealer	13.484***	2.837***	0.114**
	(0.000)	(0.000)	(0.035)
IV	0.015***	0.007***	-0.001
	(0.000)	(0.000)	(0.622)
DV	0.005***	0.008***	-0.003**
	(0.000)	(0.000)	(0.012)
$\overline{R}^2$		0.595	0.978
N	88,375	20,397	20,397

Table 5: **Impact of the Fed's ON RRP on the TPR Trading**

This table presents results of difference-in-difference regressions estimating the effects of the Fed's ON RRP—shocks to the supply of funds to dealers—on the TPR trading, including the probability of a trade over all potential trading pairs between funds and dealers, and conditional on having a trade, on trade volumes and repo rates. Panel A presents analysis comparing before and after ON RRP, and Panel B further analyze the marginal effects of changing RRP parameters, including individual caps and offer rates. "After" is a dummy which takes the value 1 for dates after the start of the RRP exercise. "Eligible" is a dummy which takes the value 1 for for eligible MMFs. Other independent variables are defined as follows: "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2). "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). Trades with the Fed are excluded in our analysis. All regressions include fixed effects to control for unobervable heterogeneity at the fund family, dealer parent, and macroeconomic levels. Heteroskedasticity-robust p-values are shown in parentheses. *, **, and ***, denotes the 10, 5, and 1 percent significance levels. Rate and spreads are measured in percentage points.

	Panel A			Panel B		
Indp. Var.	Pr(trade)	Volume	Rate	Pr(trade)	Volume	Rate
IV	0.020***	0.007***	-0.000	0.020***	0.010***	-0.000***
	(0.000)	(0.000)	(0.228)	(0.000)	(0.000)	(0.002)
DV	0.005***	0.009***	-0.002**	0.005***	0.008***	-0.000
	(0.000)	(0.000)	(0.011)	(0.000)	(0.000)	(0.222)
RS MMF	5.272***	0.550***	-0.292***	5.243***	0.518***	-0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
RS Dealer	13.317***	2.804***	0.208***	14.237***	2.893***	0.001
	(0.000)	(0.000)	(0.004)	(0.000)	(0.000)	(0.408)
Eligible	0.013	0.517***	0.118	0.017	-0.020**	-0.001**
	(0.634)	(0.000)	(0.207)	(0.527)	(0.044)	(0.010)
After	-0.048	-0.174***	-12.652***	-0.445	1.332	-0.199***
	(0.672)	(0.010)	(0.000)	(0.900)	(0.350)	(0.000)
Eligible × After	-0.335***	-0.069***	0.107***	-0.418***	-0.049***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.003)	(0.000)
Spread				0.085	-4.639	-0.012
				(0.993)	(0.256)	(0.894)
RRP cap				0.010	-0.031	0.002***
				(0.895)	(0.293)	(0.000)
Eligible × After × Cap				-0.005**	-0.008***	0.000
				(0.032)	(0.000)	(0.692)
Eligible × After × Spread				-2.601***	-0.800***	0.016***
				(0.000)	(0.000)	(0.000)
$\overline{R}^2$		0.603	0.979		0.599	0.979
N	88,375	20,397	20,397	86,845	20,200	20,200

Table 6: **Do Relationships Buffer the Impact of ON RRP on TPR Trading?**

This table presents results of regressions estimating how relationships may buffer the effects of the Fed's ON RRP—shocks to the supply of funds to dealers—on the TPR trading, including the probability of a trade over all potential trading pairs between funds and dealers, and conditional on having a trade, on trade volumes and repo rates. The approach is to interact relationship strength variables with the difference-in-difference terms in previous table. "After" is a dummy which takes the value 1 for dates after the start of the RRP exercise. "Eligible" is a dummy which takes the value 1 for for eligible MMFs. Other independent variables are defined as follows: "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2). "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). Trades with the Fed are excluded in our analysis. All regressions include fixed effects to control for unobervable heterogeneity at the fund family, dealer parent, and macroeconomic levels. Heteroskedasticity-robust p-values are shown in parentheses. *, **, and ***, denotes the 10, 5, and 1 percent significance levels. Rate and spreads are measured in percentage points.

Indp. Var.	Pr(trade)	Volume	Rate
IV	0.017***	0.008***	-0.001
	(0.000)	(0.000)	(0.116)
DV	0.007***	0.007***	0.000
	(0.000)	(0.000)	(0.978)
RS MMF	7.425***	0.642***	-0.218***
	(0.000)	(0.000)	(0.000)
RS Dealer	12.555***	2.930***	0.111
	(0.000)	(0.000)	(0.137)
Eligible	0.172***	-0.001	-0.039
	(0.000)	(0.891)	(0.703)
After	-0.105	-0.277***	-15.947***
	(0.416)	(0.000)	(0.000)
Eligible × After	-0.375***	-0.107***	0.099***
	(0.000)	(0.000)	(0.000)
Eligible × RS MMF	-3.987***	-0.319***	0.154
	(0.000)	(0.000)	(0.113)
After × RS MMF	-3.785***	-0.174***	-0.123***
	(0.000)	(0.000)	(0.001)
Eligible × After × RS MMF	3.617***	0.388***	0.431***
	(0.000)	(0.000)	(0.002)
$\overline{R}^2$		0.605	0.979
N	101,452	20,380	20,380

Table 7: **Do Relationships Buffer the Impact of Treasury Auctions on TPR Trading?**

This table presents results of regressions estimating how relationships may buffer the effects of Treasury auctions—shocks to the demand for funds by dealers—on the TPR trading, including the probability of a trade over all potential trading pairs between funds and dealers, and conditional on having a trade, on trade volumes and repo rates. "Tr. auction" is the residual (in billions of dollars) from regressing the total amount of Treasuries (excluding TIPS) allocated in the auctions on securities characteristics, maturities, and lagged auction allocation volumes. Our difference-in-difference approach is to interact relationship strength variable with "Tr. auction." Other independent variables are defined as follows: "IV" and "DV" are proxies for the sizes of investors and dealers, measured by their respective transaction volumes, in billions of dollars, over the previous month. See (1) and (2). "RS MMF" and "RS Dealer" are, respectively, the relationship strength of a fund and a dealer with respect to counterparties calculated using transactions over the previous month. See (3). Trades with the Fed are excluded in our analysis. All regressions include fixed effects to control for unobervable heterogeneity at the fund family, dealer parent, and macroeconomic levels. Heteroskedasticity-robust p-values are shown in parentheses. *, **, and ***, denotes the 10, 5, and 1 percent significance levels. Rate and spreads are measured in percentage points.

Indp. Var.	Pr(trade)	Volume	Rate
IV	0.011***	0.008***	0.001***
	(0.000)	(0.000)	(0.000)
DV	0.001**	0.016***	-0.007
	(0.034)	(0.000)	(0.283)
RS MMF	6.779***	0.593***	–0.282***
	(0.000)	(0.000)	(0.000)
RS Dealer	27.543***	9.718***	-0.143*
	(0.000)	(0.000)	(0.051)
Tr. auction	-0.028	0.047***	2.715***
	(0.187)	(0.003)	(0.000)
Tr. auction × RS Dealer	0.710**	0.037	–0.189***
	(0.015)	(0.095)	(0.001)
$\overline{R}^2$		0.715	0.977
N	84,965	23,538	23,538