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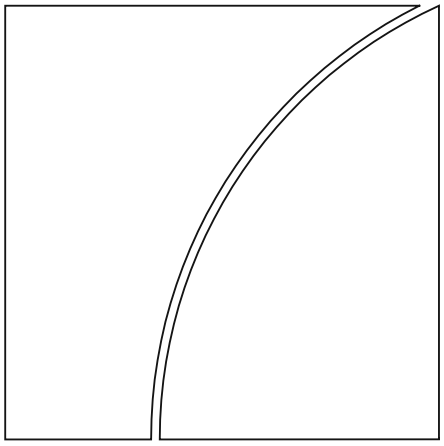

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Global Banks, Dollar Funding, and Regulation*

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ABSTRACT

We document significant and persistent price dislocations in secured and unsecured wholesale dollar funding markets between US money market funds (MMFs) and highly-rated global banks. We show that bargaining frictions affect prices in these key short-term dollar funding markets. Our identification strategy relies on a number of quasi-experiments, including the US MMF reform and quarter-end window-dressing by European banks. Post-crisis regulations have reduced competition in these markets and have generated incentives for regulatory arbitrage, which affect bargaining power and prices. Our results also highlight substantial heterogeneity across global banks of different nationalities in their behavior in dollar funding markets.

JEL classification: G15, F30, G21, G28

Keywords: global banks, dollar funding, money market funds, regulatory arbitrage, US MMF reform

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I. Introduction

US dollar funding is the lifeblood of international banking. Non-US global banks have a very large footprint in dollar banking despite their restricted access to core dollar deposits and central bank backstops. According to data from the Bank for International Settlements, they collectively held $12.6 trillion of dollar denominated assets by the end of 2017 - rivalling those of US banks. Wholesale dollar funding markets in which global banks source dollars were at the forefront during the Global Financial Crisis (GFC) and the Eurozone sovereign debt crisis. Both crises, together with post-crisis regulatory reforms, have changed the structure and functioning of these markets.[1]

One of the key sources of wholesale dollar funding for non-US banks is US money market funds (MMFs), through both unsecured and secured funding instruments.[2] The essential role of this market for the functioning of global financial intermediation materialized time and again, as stress spilled over to the rest of the financial system during the GFC (Schmidt, Timmermann, and Wermers (2016)), the 2011 Eurozone sovereign debt crisis (Chernenko and Sunderam (2014)), as well as the Covid-19 crisis (Eren, Schrimpf, and Sushko (2020a)).

We show that pricing in this very deep and liquid market for dollar funding is far from competitive, using a detailed security-level dataset of US MMF holdings of secured and unsecured instruments issued by global banks. The richness of our dataset allows us to study the underlying market frictions and identify their effects on prices. Our identification strategy is based on exogenous market disruptions during otherwise tranquil periods, which helps us to avoid the impact of the confounding factors usually present during a crisis.

We first document persistent and significant price dislocations in these wholesale dollar funding markets. Markets for both repos and unsecured instruments are highly concentrated, with the top 5 US MMF fund families taking around 60% of the respective market shares. Price dispersion, even in the secured and highly liquid repo market, can exceed 20 basis points in the cross-section of banks – after controlling for contract and time-varying bank characteristics. These deviations

[1] The literature has studied in detail dollar funding markets in the context of FX swaps and persistent deviations from covered interest parity (CIP) since the GFC (e.g., Du, Tepper, and Verdelhan (2018), Avdjiev, Du, Koch, and Shin (2019), and Abbassi and Bräuning (2020)). FX swaps are only one of the many markets used by banks to source dollars. They are also opaque, and thus do not allow for well-identified evidence of market frictions and their associated price implications.

[2] The total assets of US MMFs stood at about $3.1 trillion at end-2017 and more than a quarter (about $890 billion) of these holdings were claims against non-US banks.

can be more than twice as large for unsecured instruments, including commercial paper (CP), certificates of deposits (CD) and asset-backed commercial paper (ABCP) - even after relevant risks are accounted for.

We investigate the drivers of this price dispersion and establish the key role of bargaining frictions arising from the over-the-counter (OTC) nature of this market (Duffie, Gârleanu, and Pedersen (2005)). The structure and concentration of the market have implications for the outside options available to both funds and banks. We construct measures of market and bargaining power for funds, fund families and banks and use them to show that MMFs have substantial pricing power. Funds use their relative power to discriminate prices among highly-rated global banks, contributing to the price dispersion observed in the data. Concretely, funds charge higher prices to banks with weaker bargaining positions over and above what credit risk or other contract and bank characteristics can explain.

To establish the causal effect of bargaining power on prices, we devise an identification strategy that utilizes exogenous shocks on both the funding supply (MMFs) and demand (banks) sides, in both secured and unsecured instruments. This allows us to not only identify the effect of bargaining frictions on prices, but also to do so from multiple angles to show that they are a pervasive feature of these key short-term dollar funding markets.

The first part of our identification strategy focuses on the supply side and builds on the US MMF reform implemented in October 2016. This led to important changes in short-term dollar funding markets between US MMFs and global banks. In response to the reform, many fund families converted their prime funds – which can provide both unsecured funding and repos to banks – to government funds that can only provide secured funding in the form of repos against Treasury or agency collateral. The resulting exogenous negative supply shock in the market for unsecured funding reduced the outside options of banks and therefore led to higher market/bargaining power for prime MMFs. Indeed, we show that marginal changes in our measures of market/bargaining power increase the prices that MMFs can charge to a larger extent in the aftermath of the reform. Moreover, these results also suggest an unintended consequence of the US MMF reform, as it led to changes in market structure that exacerbated existing frictions.

We further exploit the fact that while the US MMF reform presented a negative shock to competition for unsecured funding, it had the opposite effect for repo funding. With prime funds

converting into government/Treasury funds in response to the reform, banks' outside options for funding in the repo market improved. Taking into account this effect, we compare the pricing in the unsecured funding and repo markets before and after the reform. In different specifications, we run regressions for all funds and for prime funds only. While we argue that the latter provides sharper identification since prime funds can lend in both markets, our results are similar across all specifications. In line with our hypothesis, reduced outside options in unsecured funding markets led to an increase in the relative bargaining power of funds after the reform. On the flip side, increased outside options for banks in the repo market led to a decrease in the relative bargaining power of funds in this market after the reform.

We then present a complementary strategy that leverages the heterogeneity across global banks, and builds on the structural changes in the demand for dollar funding by global banks that followed the GFC and the implementation of post-crisis banking regulations. Two developments stand out. First, after the GFC, global banks' dollar business models grew increasingly heterogeneous. European banks reduced their dollar assets and shifted towards shorter-term and more liquid dollar activities, such as short-term arbitrage of interest on excess reserves (IOER) and repo intermediation. Japanese banks, however, substantially expanded their long-term dollar lending and, as a banking system, became the largest dollar borrowers by a substantial margin. As a consequence, Japanese banks' demand for dollar grew increasingly inelastic relative to that of other banks. Second, leverage ratio regulations under Basel III were implemented inconsistently across jurisdictions. Global banks headquartered in the European Union were allowed to use end-of-period positions to calculate their regulatory leverage ratio, rather than the daily average mandated in other jurisdictions. This allowed European banks to lever up within quarters, only to retreat from repo intermediation at end-of-quarter reporting dates. We exploit both demand-side heterogeneities to further strengthen our identification of the effect of bargaining power on both secured and unsecured funding.

We first show that, following the MMF reform, a marginal increase in the bargaining power of MMFs led to a higher price of unsecured funding for Japanese relative to other banks – consistent with their relatively inelastic demand for dollar funding. This is also in line with other salient developments such as the larger cross-currency basis for the JPY/USD relative to the EUR/USD basis, and the greater demand for central bank swap lines by Japanese banks during the Covid-19

crisis.

Second, we show that the exogenous variation in the implementation of leverage ratio regulation affects pricing. It does so by temporarily reducing the bargaining power of US MMFs vis-à-vis non-EU banks, namely those that need to base their leverage ratio calculations on daily averages and hence have no incentives for quarter-end window-dressing. Non-EU banks generally obtain more favorable pricing at quarter-ends when EU banks withdraw from repo markets. In addition, we also exploit the timing of the implementation of the regulations, as well as the differences between Treasury and other collateral in the context of the overnight reverse repurchase facility of the Federal Reserve, which affects outside options and hence bargaining power.

With a key dollar funding market subject to frictions and structural changes, we investigate possible spill-overs to another key (secured) market for global banks' dollar funding – the FX swap market. Our results suggest over 65% of the variation in short-term (1-week) USD/JPY FX swap prices at quarter-ends can be explained by the exogenous window-dressing effect in repo markets.

Related literature. The main contribution of this paper is to establish bargaining frictions as an important driver of price dispersion in dollar funding markets. To do so, we build on the theoretical literature arguing that OTC frictions – in particular bargaining power – can lead to persistent price differentials (Duffie, Gârleanu, and Pedersen (2005), Duffie, Gârleanu, and Pedersen (2007), Gabaix and Maggiori (2015), Lagos, Rocheteau, and Weill (2011)). This also links our paper with the new and rapidly growing empirical literature on OTC money markets.[3] Finally, the emphasis on market structure connects our paper to the literature on the functioning and characteristics of money market funds.[4]

A growing theoretical literature introduces such frictions in international finance (Gabaix and Maggiori (2015), Malamud and Schrimpf (2018), Maggiori (2021)). Our paper is one of the few empirical studies in this field thus far. The focus on pricing of dollar funding, in particular pricing heterogeneity in the cross-section of banks, relates our work to the recent contribution by Abbassi and Bräuning (2020), who find large cross-sectional variation in the cost of dollar hedging for

[3]For instance, Han and Nikolaou (2016) find that relationships between MMFs and banks affect the likelihood and terms of trade in the tri-party repo market and help buffer demand and supply shocks. Hu, Pan, and Wang (2015) document heterogeneity in pricing across fund families. However, their main focus is haircuts for equity and corporate bond collateral. Li (2017) finds evidence of reciprocal lending relationships, whereby MMFs and banks use a "bundling" strategy across short and long term markets.

[4]See, for example, Kacperczyk and Schnabl (2013), Baba, McCauley, and Ramaswamy (2009) and Schmidt, Timmermann, and Wermers (2016).

virtually identical contracts.

We further contribute to the growing literature on the impact of global banks on the functioning of international financial markets (Ivashina, Scharfstein, and Stein (2015), Bruno and Shin (2015), Correa, Sapriza, and Zlate (2016), Bräuning and Ivashina (2020), Aldasoro, Balke, Barth, and Eren (2019), CGFS (2020)). A thriving and related literature has studied dollar funding prices in FX swaps markets and the persistent deviations from covered interest parity (CIP) since the GFC (Du, Tepper, and Verdelhan (2018), Avdjiev, Du, Koch, and Shin (2019)).[5]

While this literature has mainly focused on dollar funding through FX markets, we focus on another key market – repos and unsecured short-term funding from US MMFs. Funding is cheaper and more readily available in this market than in the FX market. The central role of short-term dollar funding by US MMFs for global non-US banks is underscored by the fact that stresses tend to reverberate through the global financial system – as during the GFC (Baba, McCauley, and Ramaswamy (2009)), the Eurozone sovereign debt crisis (Chernenko and Sunderam (2014)) or the recent Covid-19 shock (Eren, Schrimpf, and Sushko (2020b)). We show that heterogeneous funding costs can arise through OTC market frictions in repo and unsecured funding markets, which could inform the literature studying other dollar funding markets.

Our results are also related to the literature which studies how global banks react to shocks and how their behavior affects other markets. Cetorelli and Goldberg (2011), Kalemli-Ozcan, Papaioannou, and Perri (2013), and Morelli, Ottonello, and Perez (forthcoming) present evidence on the role played by global banks in the international transmission of shocks. Studying the impact of the US MMF reform, Aldasoro, Ehlers, Eren, and McCauley (2017b) and Anderson, Du, and Schlusche (2021) show that in response to the reform, banks mainly cut back on arbitrage activities and not on lending. Our results can speak to this literature since market frictions can exacerbate the impact of shocks, which itself can diversely affect global banks due to their different activities, with a varying impact on the various markets in which they participate.

A final contribution of this paper is to highlight the impact of post-crisis regulatory changes on the market structure of dollar funding markets. Munyan (2015) shows evidence of window-dressing

[5]Several explanations for this deviation have been put forward. Sushko, Borio, McCauley, and McGuire (2016) highlight the role of FX hedging demand. Cenedese, Della Corte, and Wang (2020) focus on limits to arbitrage and imbalances in the dealer-to-customer segment of the FX swap market. Iida, Kimura, and Sudo (2018), Wong and Zhang (2018) and Wong, Leung, and Ng (2017) stress the importance of counterparty risk. Rime, Schrimpf, and Syrstad (2017) argue that it is crucial to account for heterogeneity in funding costs across banks and currency areas.

in the tri-party repo market at quarter-ends due to regulatory arbitrage by European banks, whereas Anbil and Senyuz (2018) also show how this relates to the consequent take-up of the overnight reverse repurchase (ON RRP) facility by MMFs, resulting in less lending to European banks by ON RPP ineligible funds. Kotidis and Van Horen (2018) argue that the early implementation of "daily averaging" for UK banks effectively made the leverage ratio more binding. We further argue that the inconsistent implementation of leverage ratio regulation across home jurisdictions of non-US banks creates arbitrage opportunities in dollar funding markets. Du, Tepper, and Verdelhan (2018) stress the importance of bank regulations and suggest a causal link from regulation to CIP deviations.

II. Institutional background and data

US MMFs provide funding to banks both through secured instruments, most importantly as repos, and through unsecured instruments, such as CP, CD and ABCP. There are essentially three types of MMFs that interact with banks: prime funds, government funds and Treasury funds. Prime funds are allowed to invest in all four instruments, while government funds can only invest in Treasury or government agency securities as well as repos backed by these. Treasury funds, in turn, can only invest in Treasury securities or repos backed by Treasury collateral.[6]

The US MMF reform changed the interactions of MMFs and banks, as well as the structure of the market. It was implemented in response to the repeated episodes of stress in this market during the GFC and the Eurozone crisis, and required institutional prime funds and municipal funds to switch to a floating net asset value (NAV) calculation as well as introducing the possibility of imposing redemption gates and fees at the discretion of the fund. Government and treasury funds, on the other hand, were allowed to operate with stable NAVs and without any redemption gates or fees. In effect, the reform made prime funds a less attractive option for many money market investors, leading to outflows from prime funds. The reform plays a central role in our identification strategy.

Throughout our analysis, we use a rich dataset of US MMFs' portfolio holdings at month-ends obtained from Crane Data and based on the regulatory filings of US MMFs to the Securities and

[6]There are other types of MMFs such as municipal MMFs that invest in funding instruments issued by municipalities. Since we focus on dollar funding of banks, we omit municipal MMFs throughout our analysis.

Exchange Commission (SEC N-MFP forms).[7] The sample covers the universe of US MMF funds, which provide the lion's share of dollar-denominated MMF funding to non-US banks.[8] Our sample period runs from February 2011 to December 2017.[9] For each transaction, the dataset provides information on the total amount of the transaction, the instrument, the remaining maturity and the (annualized) yield, among other contract characteristics. In addition, for repos we observe whether the borrowing is backed by either Treasury, Government Agency or Other collateral. By regulation, US MMFs are only allowed to invest in dollar-denominated instruments. Therefore, all transactions are denominated in dollars.

We focus on two market segments in which MMFs act as cash lenders to banks: secured (repos) and unsecured (CP, CD and ABCP). It is important to note that unsecured funding is exclusively provided by prime MMFs, while repos can be provided by any type of MMF. Our final secured segment sample consists of a total of 205,165 contracts between 39 banks from 9 countries with 329 funds belonging to 70 fund families. The final unsecured segment sample (CP, CD and ABCP) consists of 538,848 observations linking 49 banks from 14 countries with 175 funds belonging to 66 fund families.[10,11]

Other data we use are obtained as follows. We retrieve the Call Reports of subsidiaries, branches and agencies of foreign banks operating in the United States from the Federal Reserve Bank of Chicago (FFIEC 002) and Federal Financial Institutions Examination Council's Central Data Repository (FFIEC 031/041 and FR 2886b). We collect all relevant balance sheet items for all reporting banks. We aggregate them first by bank (aggregating the different branches and agencies

[7] In the earlier part of the sample, Crane Data differs slightly from the SEC N-MFP filings, covering around 92% of the US MMF universe. The 8% difference in the earlier sample is due to internal funds that manage cash for their fund families. As of end-December 2017, however, the totals reported in the SEC N-MFP (obtained from the OFR Money Market Monitor) and ICI (another data provider) are almost identical to Crane Data.

[8] Non-US banks also obtain funding from dollar MMFs domiciled outside the United States (Aldasoro, Eren, and Huang, 2021). Over the period 2013-2017, offshore dollar repo funding accounted on average for 9% of total MMF dollar repo funding for non-US banks, whereas for unsecured funding the equivalent figure stood close to 24%.

[9] We do not include data from 2018 onwards due to some structural changes that affected these markets. First, the corporate tax reform in the US significantly altered the outside options and investment behavior of MMFs. This was due to the fact that at the same time as the tax reform, there was an increase in Treasury bill supply, pushing yields higher than those on ON RRP. MMFs held more bills and reduced their take-up of ON RRP as a result.

[10] Since US banks are also active in these markets, we include them in the analysis. However, our results are not sensitive to their exclusion.

[11] In the Internet Appendix, we provide summary statistics by country of headquarters and markets. In particular, Table VIII presents information on the banks included in the sample, their country of headquarters, and their activity in both secured and secured markets. Table IX presents summary statistics on the number of banks, funds, fund families, average contract size, maturity and prices of both repo and unsecured funding, aggregated at the bank nationality level).

of the same bank) and then we link this to the country of headquarters. The sample period runs from the first quarter of 2000 to the fourth quarter of 2017. To calculate the global dollar positions of banks by nationality, we use the quarterly BIS locational and consolidated banking statistics. We obtain daily CDS data for the banks in our final sample from Markit. We use the 5 year senior tier security mid-spread, keeping end-of-month observations. Finally, we retrieve daily currency basis spreads and LIBOR from Bloomberg and use the mid-price, end-of-month observations.

III. Pricing of dollar funding: the role of market structure

In this section, we study the pricing of contracts between US MMFs and banks for both secured and unsecured instruments, provide facts about the industrial organization of this market, and construct measures of market/bargaining power. First, we show that prices exhibit a wide dispersion in the markets where MMFs interact with highly-rated global banks. Dispersion remains even after filtering out contract characteristics and counterparty risks – suggesting that the market is not perfectly competitive. Next, we show that the US MMF sector is concentrated: a few fund families and funds provide most of the funding global banks obtain from this sector. Importantly, these markets are not centralized, but transactions occur in an OTC market setting. Hence, they are subject to OTC market frictions, potentially leading to non-competitive pricing (Duffie, Gârleanu, and Pedersen, 2005). Finally, we construct measures of market power and bargaining power for both MMFs and banks, setting the stage for the next section, where we use an exogenous shock that impacted market structure, namely the US MMF reform, as part of our identification strategy to show the causal effect of market/bargaining power on prices.

A. Price dispersion

In a perfectly competitive market, contracts with the same risk characteristics should be priced the same. As a first-order check, we run the following regression controlling for a host of contract characteristics and unobserved counterparty risks:

$$Rate_{bfct} = \alpha_1 Log(value_{bfct}) + \alpha_2 Rem.maturity_{bfct} + \eta_{bt} + \eta_{t,inst(c)} + \epsilon_{bfct} \quad (1)$$

where b denotes banks, f denotes funds, c denotes the contract and t denotes the time period. We run this regression separately for unsecured and repo contracts. On the left hand-side of Figure 1, we plot the residuals ϵ_{bfct}, which capture the unexplained component of the price a bank pays for unsecured instruments after controlling for contract characteristics, including $Log(value_{bfct})$, which is the size of the contract and $Rem.\,maturity_{bfct}$, which is the remaining maturity (which we use as a proxy for maturity throughout the paper)[12] and time-varying instrument characteristics, $\eta_{t,inst(c)}$, that capture the average pricing of CPs, CDs or ABCPs in a given time period. Finally, in order to capture time-varying counterparty risk, we use bank-date fixed effects, η_{bt}. On the right-hand side of Figure 1, we use a similar specification for repo markets, where the $\eta_{t,inst(c)}$ represent collateral-date fixed effects.

Despite the breadth of control variables used, the range of the unexplained price dispersion remains large. This is especially the case for unsecured instruments: the difference between the 25th and the 75th percentile is around 40 basis points, with the overall range of residuals reaching around 100 basis points – compared to an average rate of about 40 basis points in our sample. For repos, the price dispersion is smaller, yet still economically significant. These contracts are effectively risk-free, and especially after controlling for relevant contract characteristics and counterparty risks, any remaining price dispersion should be negligible. Importantly, given the large size of both markets, even a few basis points amount to an economically large difference in aggregate funding costs.

B. Market structure and relationships

A key structural feature of the US MMF industry giving rise to non-competitive pricing is its high concentration – which increased further following the US MMF reform, especially in the unsecured segment.[13] Figure 2 plots the total market share of the top 5 fund families providing repo and unsecured (CP, CD and ABCP) funding to banks in the sample. For repo funding, this share has been roughly around 60% and the share of the top 15 funds around 50% prior to the MMF reform, but has increased to around 60% after the MMF reform. For unsecured funding, the market share of the top 5 fund families was between 50% and 60% before 2016, and increased to

[12] We do not observe original maturity. Using remaining maturity could potentially create a bias if some banks systematically borrow on the same day of the month only. While we cannot fully address this concern with the available data, banks are generally active and have a variety of maturities remaining at month-ends.

[13] We discuss the reform in more detail in Section IV.

Figure 1
Price dispersion in money market instruments after taking into account contract and time-varying bank characteristics

Sources: Crane data; authors' calculations. *Notes:* Box plot of the residuals from estimating Equation 1, where the price is regressed on time-varying contract and bank characteristics, done separately for each segment.

more than 80% after the reform, or from around 60% to 90% for the top 15 funds.

Banks form fairly persistent trading relationships with MMFs. Persistent relationships are a feature of OTC markets more generally, reflecting costs of finding new counterparties to trade with (Duffie, Gârleanu, and Pedersen (2005), Chernenko and Sunderam (2014), Han and Nikolaou (2016)). In our data, a significant share of trading relationships at the end of the sample had already been present at the beginning of the sample (see Figure 3). In December 2017, 26.7% of unsecured contracts and 37.4% of repo contracts were between banks and fund families that had a trading relationship since the beginning of the sample. On the other hand, only 2.2% of unsecured contracts and 8.1% of repo contracts were among banks and fund families that started trading a year before.[14]

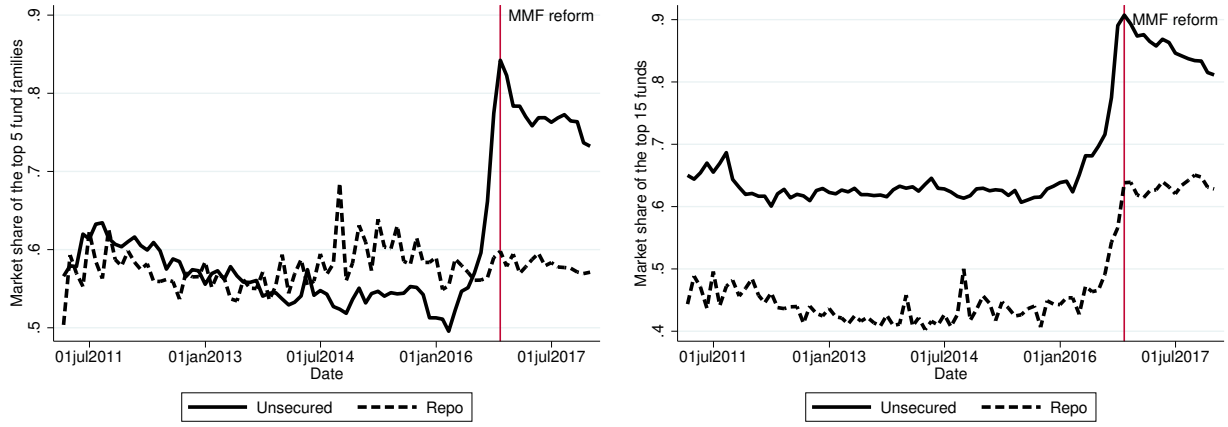
C. Measures of market and bargaining power

Against the background of persistent price dispersion and market concentration, in this section we construct multiple measures of market and bargaining power, and test whether they causally

[14]We control for relationship length in all regressions. The US MMF reform led to the formation of some new relationships. In the Internet Appendix, we redo Figure 3 to show that the density of older relationships was higher prior to the MMF reform (see Figure 10). We also show that persistent relationships sheltered banks from losing funding from MMFs, as funds were forced to reduce the amount of unsecured funding following the US MMF reform (see Table X)), similar to the findings of Chernenko and Sunderam (2014) during the Eurozone crisis.

Figure 2
MMF concentration - Market share of the top fund families and funds

Top 5 fund families *Top 15 funds*



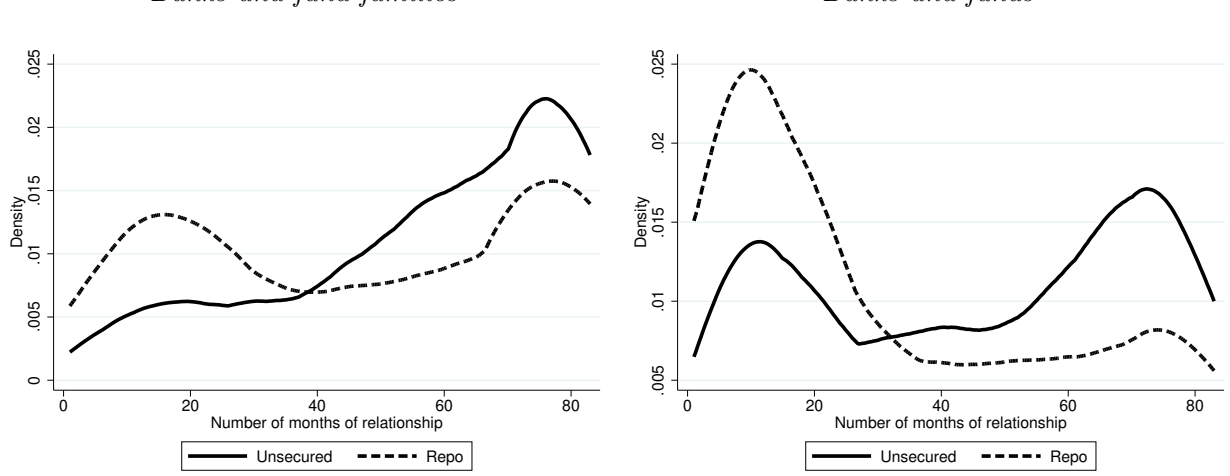
Sources: Crane data; authors' calculations.

affect pricing in the next section.

When computing these measures we take into account the fact that banks and MMFs interact in an OTC market in which other counterparties are in principle available to them as outside options. We include measures of market/bargaining power from the point of view of both MMFs (the supply-side of dollar funding) and banks (the demand side) separately in our regressions. When we construct measures for funds, we do so both at the fund and fund family levels in order to allow for the possibility that a fund's bargaining power vis-à-vis a bank may not necessarily stem from itself but also the fund family it belongs to. There is potentially relevant information if one measure explains pricing better than the other, in particular as the literature provides little guidance on this question thus far.

Our first measures are simple market share indicators, MS. We construct these for funds, fund families and banks by calculating the share within the total volume of funding that they account for in each segment, $s \in \{repo, unsecured\}$, at any given date. Throughout the paper, we denote banks with b, funds with f and fund families with f^*. We denote the total number of banks in segment s by B^s, funds by F^s and fund families by FF^s. We also denote the number of banks that a fund interacts with as B^s_f, the number of banks that a fund family interacts with as B^s_{f*} and the

Figure 3
Density of the number of total months of relationships as of 31 December 2017



Sources: Crane data; authors' calculations.

number of funds and families that a bank interacts with as F_b^s and FF_b^s, respectively.

$$MS_{ft}^s = \frac{\sum_{b=1}^{B_f^s} Value_{bft}^s}{\sum_{f=1}^{F^s}\sum_{b=1}^{B_f^s} Value_{bft}^s} * 100 \tag{2}$$

$$MS_{f^*t}^s = \frac{\sum_{b=1}^{B_{f^*}^s} Value_{bf^*t}^s}{\sum_{f^*=1}^{FF^s}\sum_{b=1}^{B_{f^*}^s} Value_{bf^*t}^s} * 100 \tag{3}$$

$$MS_{bt}^s = \frac{\sum_{f=1}^{F_b^s} Value_{bft}^s}{\sum_{b=1}^{B^s}\sum_{f=1}^{F_b^s} Value_{bft}^s} * 100 \tag{4}$$

where MS_{ft}^s is the market share of a fund in each segment s, $MS_{f^*t}^s$ is the market share of a fund family in each segment s and finally, MS_{bt}^s is the market share of a bank in each segment s.[15]

We expect that funds and fund families with higher market shares (MS_{ft} and MS_{f^*t}, respectively) charge higher prices, all else constant. Similarly, we expect that a bank with higher market share (MS_{bt}) can obtain lower prices, due to a greater availability of outside options.

Our second set of measures digs deeper into the OTC market structure, with the aim of exploiting the relative bargaining power that a bank or fund (family) has. Concretely, they capture the importance of a given bank for a given fund or fund family as well as, vice versa, the importance of a given fund or fund family for a bank. Importantly, these measures better capture the inten-

[15] Note that each individual contract forms a negligible part of the overall portfolios for any bank-fund or bank-fund family pair.

sity of the counterparty relationships than the market share or the number of relationships each counterparty has, and thereby better reflect outside options. Moreover, since the measures are at bank-fund-date level, we can use fixed effects to control for unobserved effects at the bank-date or fund-date level. This allows us to control for time-varying supply and demand factors and to zero in on the pricing of a contract for a given relationship between an MMF and a bank.

Again, we construct these measures for each segment separately. The intuition is the following: If a bank relies heavily on a given lender, then the lender can be expected to have higher "bargaining power". Similarly, if a borrower bank is important within the portfolio of a given lender, then the bank should have more bargaining power. We construct our measure of fund bargaining power (FBP) by zooming in on the share of funding that a given bank receives from a given fund:

$$FBP^s_{bft} = \frac{\sum_{b,f} Value^s_{bft}}{\sum_{f=1}^{F^s_i} Value^s_{bft}} * 100 \tag{5}$$

where $\sum_{b,f} Value^s_{bft}$ is the total dollar amount of outstanding contracts between a bank b and a fund f at time t in segment s and $\sum_{f=1}^{F^s_b} Value_{bft}$ is the total dollar amount for bank b at time t in segment s, where F^s_b is the total number of funds the bank interacts with in segment s. For the dependence of a given bank on a given fund family, the indicator $FBP_{bf^*t^s}$ is constructed in the same manner, but replacing fund f with fund family f^*.

To construct the indicator of bank bargaining power (BBP) we take the complementary perspective, by calculating the share of a given fund f's funding that goes to a given bank b at time t:

$$BBP^s_{bft} = \frac{\sum_{f,b} Value^s_{bft}}{\sum_{b=1}^{B^s_f} Value^s_{bft}} * 100 \tag{6}$$

where $\sum_{f,b} Value^s_{bft}$ represents the total dollar amount of outstanding contracts between fund f and bank b at time t in segment s, and $\sum_{b=1}^{B^s_f} Value^s_{bft}$ is the total dollar amount transacted by fund f in the same date in segment s, with B^s_f representing the number of banks fund f interacts with in segment s. The measure for fund families, $BBP^s_{bf^*t}$, is constructed analogously.

In Table I, we present summary statistics of these measures in the unsecured and repo segments. The average market shares of fund families and banks are notably larger in the repo segment.

Bank bargaining power in the unsecured segment is on average larger than other bargaining power measures in the same segment, but also shows considerably larger dispersion.

Table I
Summary statistics of bargaining power measures (per cent) and interest rates (bps)

	(1)	(2)	(3)	(4)
Segment:	Unsec.	Unsec.	Repo	Repo
Measures:	Mean	St. Dev.	Mean	St. Dev.
MS_{ft}	1.92	2.91	1.29	1.60
MS_{f^*t}	6.68	6.69	9.38	6.78
MS_{bt}	3.59	1.73	5.99	3.59
FBP_{bft}	6.40	5.39	14.40	13.51
BBP_{bft}	3.60	7.07	3.20	6.56
FBP_{bf^*t}	5.97	4.97	10.60	10.02
BBP_{bf^*t}	10.84	13.19	15.88	16.28
Dep. Var:				
$Rate_{bfct}$	46.30	39.42	39.46	37.25

Before moving to our identification strategy, we first explore how our measures of bargaining power are related to prices in each segment in simple, non-causal regressions. First, higher FBP_{bft} or FBP_{bf^*t} should mean higher prices, all else constant. In other words, if a fund or fund family provide a larger share of a bank's funding in a given segment, they will have a higher bargaining power as the bank has fewer outside options vis-à-vis that fund (family). Second, a larger value of BBP_{bft} or BBP_{bf^*t} should be associated with lower prices, as it indicates that a given bank accounts for a larger share of lending of a fund or a fund family, lowering the lender's outside options and increasing the bargaining power on the side of the bank.

To evaluate whether market shares and bargaining power correlate with prices with the expected sign, we first run regressions of prices on these measures, controlling for a host of observed and unobserved factors for the whole sample.[16] Table II presents the results for the market share (columns (1)-(4)) and bargaining power measures (columns (5)-(8)). The market and bargaining power indicators affect pricing in the predicted direction and are statistically significant in most cases.

Columns (1)-(2) show the results in the repo segment with the market share of funds at the

[16]Controls include the logarithm value of the contract, the 5-year CDS spread of the bank to control for credit risk, the remaining maturity of the contract, the length of the relationship between the bank and the fund (family) and the total amount transacted in a given period between a bank and a fund (family). In addition, we also control for $instrument * date$ fixed affects and, depending on the specification, for $fund\ type * date$ fixed effects.

Table II

Market share and bargaining power measures: association with prices

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Segment:	Repo	Repo	Unsec.	Unsec.	Repo	Repo	Unsec.	Unsec.
Measures:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
MS_{ft}	0.07		0.33***					
	(0.15)		(0.11)					
MS_{f^*t}		0.24***		0.04				
		(0.04)		(0.06)				
MS_{bt}	-0.11***	-0.07	0.11	-0.06				
	(0.04)	(0.04)	(0.08)	(0.06)				
FBP_{bft}					0.07***		0.03	
					(0.02)		(0.02)	
BBP_{bft}					-0.02		-0.10***	
					(0.01)		(0.04)	
FBP_{bf^*t}						0.06***		0.01
						(0.01)		(0.02)
BBP_{bf^*t}						-0.06***		-0.08*
						(0.01)		(0.04)
Control vars:								
$Log(value_{bfct})$	-0.16	0.09	-0.48**	-0.30	-0.15	0.02	-0.42*	-0.30
	(0.14)	(0.11)	(0.23)	(0.21)	(0.13)	(0.12)	(0.23)	(0.20)
$5yCDS_{bt}$	0.02***	0.02***	0.04***	0.04***	0.02***	0.02***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Rem.mat_{bfct}$	0.36***	0.35***	0.06***	0.06***	0.36***	0.35***	0.06***	0.06***
	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)
$Rel.length_{bft}$	0.03***		0.01		0.03**		0.01	
	(0.01)		(0.03)		(0.01)		(0.03)	
$Rel.length_{bf^*t}$		0.02*		0.06***		0.02**		0.06***
		(0.01)		(0.02)		(0.01)		(0.02)
$TotVolume_{bft}$	0.16*		-0.08		0.00		0.61**	
	(0.09)		(0.29)		(0.13)		(0.31)	
$TotVolume_{bf^*t}$		-0.06		0.19**		0.06		0.23***
		(0.04)		(0.10)		(0.04)		(0.06)
Observations	181,425	181,425	268,966	268,966	181,425	181,425	268,966	268,966
R-squared	0.87	0.87	0.88	0.88	0.87	0.87	0.88	0.88
Date*FundType FE	✓	✓			✓	✓		
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest rate (in basis points) paid by a bank when borrowing from a fund in the full sample period. MS_{ft}, MS_{f^*t} and MS_{bt} refer to the market share of the fund, fund family and the bank, respectively, in the given segment (repo or unsecured) of the market. FBP_{bft} (f^*) refers to the share of a fund (fund family) for a bank at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). BBP_{bft} (f^*) refers to the share of a bank for a fund (fund family) at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). Controls include $Log(value_{bfct})$ and $5y\,CDS_{bt}$, $Rem.\,maturity_{bfct}$, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$ and $TotVolume_{bf^*t}$, depending on the specification, which measure the log size of the contract, 5-year CDS spread of the bank, the remaining maturity of the contract (taken as a proxy for maturity), the length of the relationship of the fund (or fund family) and the bank in the given segment and the total volume of contracts between a fund (or fund family) and a bank in a given segment at a given date. Instrument is one of ABCP, CP or CD in the unsecured segment and collateral type in the repo segment (Treasury, Agency or Other). Date*Fund Type FE are omitted in columns (3), (4), (7) and (8) since only prime funds provide unsecured funding. Standard errors clustered at the fund level are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

fund level in (1) and at the fund family level in (2). Columns (3)-(4) follow the same structure but for the unsecured segment. We find that the coefficients on the market share of the fund and fund family have the predicted positive sign across all columns, but are statistically significant only in columns (2) and (3). The coefficient on the market share of the bank has the predicted negative sign in columns (1), (2) and (4), but is statistically significant only in column (1).

Results using the measures that capture the importance of a counterparty as reflected by FBP and BBP are reported in columns (5)-(8). Columns (5)-(6) show the results for the repo segment with the BBP measures constructed at the fund and fund family levels respectively. Columns (7)-(8) show the analogous results for the unsecured segment. In each column, the estimated coefficient is of the hypothesized sign, i.e. a higher fund bargaining power is associated with a higher price, and vice versa for banks' bargaining power. Results are particularly strong in the repo segment, especially with the indicators at the fund family level.

In terms of economic significance, these results suggest that the impact of the frictions can be material, especially given the size of these and other related markets subject to similar frictions,[17] and since most of our sample period covers a zero interest rate environment. To give a sense of magnitudes, for example, in the unsecured segment, a 10 percentage point increase in the market share of a fund corresponds to 3.3 basis point higher prices (compared to the 42 basis points average in the sample). Moreover, these frictions tend to intensify during stress episodes, as we show with the substantial rise in our measures during the MMF reform (See Figures 2 and 4). [18]

We also report the coefficients on other control variables, as they help to understand price setting in these markets.[19] As expected, a higher CDS spread is correlated with a higher price, as are longer maturity contracts. This maturity or term premium is larger for repo contracts compared to unsecured contracts, in line with the fact that repo maturities are generally shorter. Relationship length and price are positively correlated, suggesting that building new relationships is costly and MMFs are able to extract rents from longer-term counterparties.[20] The total volume of funding

[17] As we document in this paper, the total assets of non-US banks stand above $12 trillion and other US banks and other entities also take part in similar markets.

[18] See also Eren, Schrimpf, and Sushko (2020a) for the increase in price dispersion in these markets during the Covid-19 episode).

[19] Control variables are not reported in the rest of the tables in the main body of the paper to save space, but coefficients are similar.

[20] In the Internet Appendix, we show that funds were less likely to cut ties with banks they had a longer relationship with in the aftermath of the MMF reform, suggesting that higher prices in normal times could be justified as they shelter banks from funding losses in stress times. This is in line with the findings of the relationship lending literature.

from funds to banks is mostly insignificant, but in some cases positive, potentially reflecting similar dynamics at play.

In the Internet Appendix to this section, we provide several robustness checks to show that using different timing to measure these variables (i.e. whether observations at t or $t-1$ are used) has little to no effect on the association with prices. We also report the R^2 with various specifications in order to gauge how the bargaining power measures help explain the variation in prices. *Date* fixed effects already account for a substantial portion of the explained variation, making the marginal contribution of all other variables rather low. When we only include the bargaining measures as independent variables, the R^2 is 5.01% in the unsecured segment and 4.24% in the repo segment. If we also include other "non-standard" variables measuring frictions, such as relationship controls (i.e. $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$, and $TotVolume_{bf^*t}$), the R^2 increases to 42.42% in the unsecured market and to 27.80% in the repo market. Overall, these results suggest that macro and risk variables do have the most explanatory power, but other frictions can also account for relevant variation in the data.

Taken together, results for the full sample suggest that our measures can be useful in understanding pricing in these markets. In the next section, we make use of quasi-experiments to properly identify the effect of these variables. In particular, we focus on the period around the US MMF reform. Figure 1 suggests that dispersion in prices was the highest in this period, in principle suggesting a larger role of frictions than in the full sample.

IV. The US MMF reform as a quasi-experiment

To formally test and identify the causal effect of market and bargaining power on prices, we start by exploiting the US MMF reform. First, we establish the relevant institutional details of the US MMF reform. Next, we argue that the reform was an exogenous negative supply shock to unsecured funding and thereby reduced outside options for banks. We present results for the unsecured segment, and then compare pricing in unsecured and repo markets, leveraging the different impact of the reform across the two markets. This section represents the core of our identification strategy. We complement this with an additional identification strategy (focusing only on the repo market) in Section V.

A. The US MMF reform

The US MMF reform required institutional prime funds and municipal funds to switch to a floating net asset value (NAV) calculation and introduced the possibility of imposing redemption gates and fees at the discretion of the fund. Government and Treasury funds, on the other hand, were allowed to operate with stable NAVs and without any redemption gates or fees. Stable NAV funds promise to keep the NAV at a minimum of 100% of the invested amount (or at 100 cents on the dollar). In contrast, investors may face losses in the case of floating NAV funds. In addition, the introduction of redemption gates and fees led to worries that investors may not be able to withdraw their funds in episodes of market stress. During the GFC, prime funds were still operating with stable NAV and when the NAV of the oldest MMF (Reserve Primary Fund) fell below 100 cents on the dollar, it triggered a market-wide panic and a broad run on MMFs. Both floating NAVs and the introduction of redemption gates and fees were aimed at preventing these types of runs, by taking away the implicit promise of no losses due to stable NAVs for institutional prime fund investors.

The reform effectively made prime funds an unattractive option for many money market investors and led to outflows from these funds. In response, a large number of fund families converted many of their prime funds to government and Treasury funds, which are restricted in their investment to repos and short-term government securities. As only prime funds are allowed to provide unsecured funding, the unsecured funding that banks received from MMFs fell substantially, from around $536 billion on average in the year prior to the reform to $239 billion in the year after the reform.

The reform became effective on October 14, 2016. The transition towards the reform started in January 2016, but was most intense around the actual implementation date (Aldasoro, Ehlers, Eren, and McCauley, 2017b; Aldasoro, Balke, Barth, and Eren, 2019). Even though the reform was announced in 2014, there is no evidence that any noticeable changes took place before the actual transition period that started in January 2016 (see Figure 2). This relatively fast transition is likely due to the relatively short-term nature of MMF holdings and the fact that prime fund closures only accelerated in 2016 (in particular during the summer).

Hence, the decline of unsecured funding represented a negative supply shock for banks, reducing

their outside options. We also study the repo market, which represents the flip side of unsecured markets. In repo markets, increased competition through the entry of new players increased the outside options of banks. The differential impact of the reform on these two markets is an important feature we exploit in our identification strategy. Notably, the reform occurred during an otherwise tranquil period in financial markets. This allows us to zero in on the pricing power channel without the presence of other confounding factors – especially those related to counterparty credit risk. We view this as a crucial advantage of our identification strategy.

B. The impact of the reform on unsecured funding markets

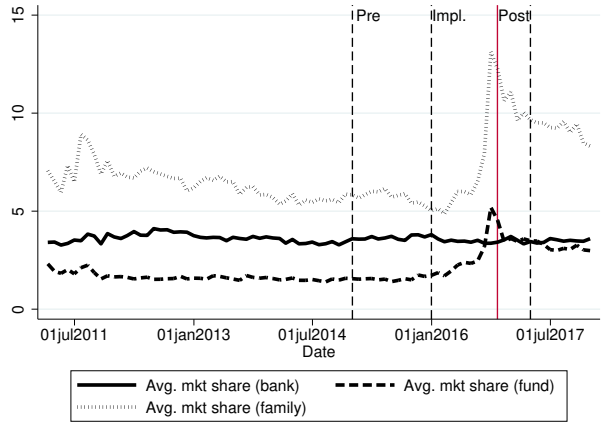
In this section, we exclusively focus on unsecured funding, provided only by prime funds. In order to identify the effect of the market structure variables of interest, we compare the period before and after reform implementation. In our baseline results, we take the "pre-period" as the year prior to the start of implementation, that is between 1 January 2015 and 31 December 2015. The "post-period", comprises the six months after the reform was fully implemented, that is between 14 October 2016 and 31 March 2017. We keep the "post-period" relatively short, since banks reacted to the loss of prime MMF funding by finding other sources of funding (Aldasoro, Ehlers, Eren, and McCauley, 2017b; Aldasoro, Balke, Barth, and Eren, 2019), leading to a potential structural change in the dynamics of interactions with MMFs.[21]

At the heart of our identification strategy lies the fact that, in the context of fund closures and overall volume decline, funds (or families) saw an exogenous increase in their market/bargaining power merely by staying open for business. In Figure 4, we show the time series of the average values of our market/bargaining power measures. In the first panel, we show that indeed the average market share of both funds and fund families increased after the reform. However, the average market share of banks remained flat throughout. Similarly, in the second panel, we show that the average fund bargaining power (FBP) also increased in response to the reform. On the other hand, the bank bargaining power (BBP) measures remained roughly similar on average in the "pre-period" and the "post-period" – even though they did increase temporarily during the implementation period.

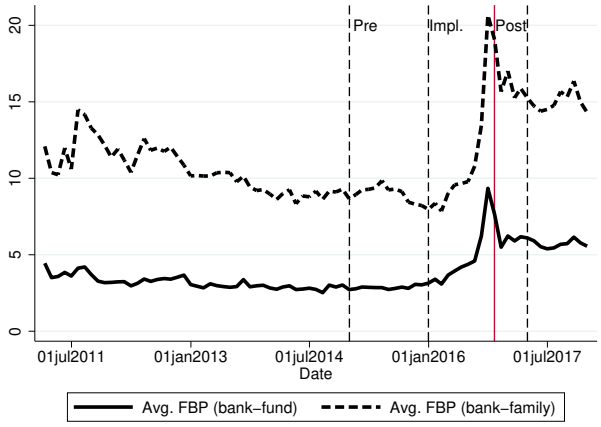
[21] In the Internet Appendix we present robustness checks varying the post-reform periods, such as using nine or twelve-month windows for the "post-period" or comparing 2015 with 2017. Our results remain qualitatively unchanged.

Figure 4
Average values of market/bargaining power indicators

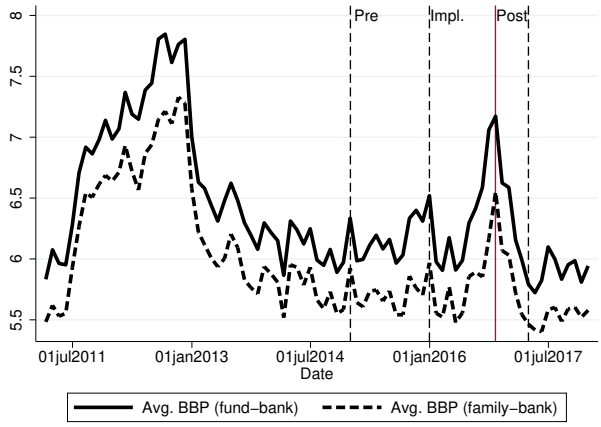
Average market shares



Average FBP_{bft} and FBP_{bf^*t}



Average BBP_{bft} and BBP_{bf^*t}



Notes: the vertical red lines denote the final implementation date of the the MMF reform (start of the post-reform period). Dashed black lines denote respectively the start of the pre-reform period, the start of the implementation period, and the end of the post-reform period. FBP and BBP refer to fund bargaining power and bank bargaining power, respectively defined in Equations 5 and 6. Each can be measured at the fund (f) or fund family (f^*) level.
Sources: Crane data; authors' calculations.

Our main hypothesis is the following: We expect that if a fund commands the same market share before and after the reform, it can charge a higher price after the reform. A surviving fund would have a greater bargaining power since banks' outside options are limited after the reform, following the decline in the number of counterparties. Analogously, for the FBP measures – if a fund commands the same share in a banks' borrowing before and after the reform, we expect it to translate into higher prices after the reform, all else equal. For example, if a fund's share in a bank's

borrowing increases by 10% either before or after the reform, we expect the marginal effect of this on fund pricing power to be greater after the reform, since the bank has lower outside options after the reform as it has fewer counterparties to source funding from. As the main impact of the reform was a reduction in the number of funds, we expect the main effect to be on the funding supply side, i.e. our measures for fund (or fund family) market/bargaining power.

We run the following regressions using, first, the market share variables, and second, the bargaining power measures (FBP and BBP), while always including a rich set of controls and fixed effects to strip out potential confounding factors:

$$\begin{aligned} Rate_{bfct} = \phi_1 MS_{ft} + \phi_2 \mathbb{1}(Post_t) * MS_{ft} + \phi_3 MS_{bt} + \phi_4 \mathbb{1}(Post_t) * MS_{bt} \\ + \Phi_5 X_{bfct} + \eta_{t,inst(c)} + \eta_b + \eta_f (+\eta_{bf}) + \epsilon_{bfct} \end{aligned} \tag{7}$$

$$\begin{aligned} Rate_{bfct} = \gamma_1 FBP_{bft} + \gamma_2 \mathbb{1}(Post_t) * FBP_{bft} + \gamma_3 BBP_{bft} + \gamma_4 \mathbb{1}(Post_t) * BBP_{bft} \\ + \Gamma_5 X_{bfct} + \eta_{t,inst(c)} + \eta_{bt} + \eta_{ft} (+\eta_{bf}) + \epsilon_{bfct} \end{aligned} \tag{8}$$

The vector of controls X_{bfct} includes $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.\,maturity_{bfct}$, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$ and $TotVolume_{bf^*t}$ which respectively measure the log size of the contract, 5-year CDS spread of the bank as a proxy of credit risk, the remaining maturity of the contract (taken as a proxy for maturity), the months passed since the beginning of the relationship of the fund (or fund family) and the bank in the given segment, and the total volume of contracts between a fund (or fund family) and a bank in a given segment at a given date. Fixed effects include $Date * Instrument$ fixed effects in all specifications, bank and fund fixed effects in regressions using market shares, and $Bank * Date$ and $Fund * Date$ fixed effects in regressions using bargaining power measures. In addition, for each regression, we present results both with and without $Bank * Fund$ fixed effects. We run these regressions with measures both at the fund and family level, adjusting relevant controls at the bank-fund-date level to their counterparts for fund families.

According to the preceding discussion, in particular, we expect ϕ_2 and γ_2 to be positive in

equations (7) and (8), respectively.

We present the results in Table III. Columns (1) and (2) focus on the market share measures and controls at the fund level (equation (7)). We control for unobserved bank and fund characteristics by using bank and fund fixed effects in column (1) and in column (2) we take into account bank-fund interaction fixed effects as a richer set of controls. We also partial out the average prices for each instrument (CP, CD, ABCP) at a given date to control for market variation in borrowing rates by using date-instrument fixed effects. To capture possible price effects of bank-fund relationships we include $RelLength_{bft}$ and $TotVolume_{bft}$ in the regression, which measure the length of the relationship between the bank and the fund as well as the total unsecured borrowing volume at a given date, respectively. In columns (3) and (4), we include the same fixed effects as in column (1) and (2), respectively, but replace all other measures that are calculated at the fund level with their counterparts at the fund family level. Columns (5) and (6) are similar to (1) and (2), and (7) and (8) are similar to (3) and (4), but using bank and fund (family) bargaining power measures instead of market shares (equation (8)).

The specifications with bargaining power measures are preferred to those with market shares for at least two reasons. First, as they are at the bank-fund (family)-date level, they capture the intensity of the relationship and how important each counterparty is to one another. Second, they allow for a richer set of controls to strip potential confounding effects. In particular, we can employ bank-date fixed effects to capture changes in the demand for funding by banks and also fund (family)-date fixed effects to control for changes in the supply of funding by funds (families). We also include bank-fund fixed effects to capture the average price in the relationship. This allows us to zero in on the bargaining power variables, once time-varying supply and demand factors as well as relationship factors are controlled for.

The results overall provide support to our hypothesis that the exogenous reduction in supply of unsecured funding in response to the MMF reform increased the market/bargaining power of funds. The first four columns show that, measured both at the fund or fund family level, a given market share resulted in higher prices after the reform. Also, as conjectured, the impact of a bank's market share did not change after the reform. The second set of results in columns (5)-(8) are also in line with our conjectures overall: If a fund or a fund family was more important from the point of view of a bank – i.e. it provided a greater share of the bank's funding – they could charge the bank a

Table III

Identification of market power using the MMF reform as an exogenous shock

Measure:	(1) B-F $Rate_{bfct}$	(2) B-F $Rate_{bfct}$	(3) B-FF $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$	(5) B-F $Rate_{bfct}$	(6) B-F $Rate_{bfct}$	(7) B-FF $Rate_{bfct}$	(8) B-FF $Rate_{bfct}$
MS_{ft}	-2.27***	-1.98**						
	(0.78)	(0.85)						
$\mathbb{1}(Post_t) * MS_{ft}$	2.09***	1.93***						
	(0.61)	(0.66)						
MS_{f^*t}			-0.95***	-0.89**				
			(0.35)	(0.35)				
$\mathbb{1}(Post_t) * MS_{f^*t}$			0.92***	0.94***				
			(0.33)	(0.30)				
MS_{bt}	-1.70***	-1.49***	-1.64***	-1.51***				
	(0.26)	(0.28)	(0.28)	(0.30)				
$\mathbb{1}(Post_t) * MS_{bt}$	0.11	0.16	0.03	0.10				
	(0.27)	(0.28)	(0.24)	(0.27)				
FBP_{bft}					0.01	-0.03		
					(0.03)	(0.04)		
$\mathbb{1}(Post_t) * FBP_{bft}$					0.14	0.11*		
					(0.09)	(0.06)		
BBP_{bft}					-0.03	-0.05		
					(0.04)	(0.05)		
$\mathbb{1}(Post_t) * BBP_{bft}$					-0.04	-0.15		
					(0.10)	(0.11)		
FBP_{bf^*t}							0.06***	-0.01
							(0.02)	(0.02)
$\mathbb{1}(Post_t) * FBP_{bf^*t}$							0.10*	0.09**
							(0.05)	(0.05)
BBP_{bf^*t}							-0.01	0.01
							(0.06)	(0.06)
$\mathbb{1}(Post_t) * BBP_{bf^*t}$							-0.05	-0.17
							(0.13)	(0.12)
Observations	59,613	59,315	59,613	59,315	59,568	59,270	59,568	59,270
R-squared	0.87	0.90	0.87	0.90	0.91	0.93	0.91	0.93
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE	✓		✓					
Fund FE	✓		✓					
Bank*Fund FE		✓		✓		✓		✓
Bank*Date FE					✓	✓	✓	✓
Fund*Date FE					✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank when borrowing from a fund. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and March 2017 (both included) as the "post-period." January 2016 - September 2016 corresponds to the reform implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 – the implementation date of the reform. Controls in all columns include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.\,maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification). Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

higher price after the reform (see the coefficients on $\mathbb{1}(Post_t) * FBP_{bft}$ and $\mathbb{1}(Post_t) * FBP_{bf^*t}$). Again, the coefficients measuring the bank bargaining power after the reform are not statistically significant (see the coefficients on $\mathbb{1}(Post_t) * BBP_{bft}$ and $\mathbb{1}(Post_t) * BBP_{bf^*t}$). In other words, if a bank was receiving a greater share of a funds' lending (i.e. the bargaining power of a bank was higher) it did not result in a change in prices. On the other hand, if a bank received a greater share of funding from a fund (i.e. a fund's bargaining power was higher), it saw an increase in prices.

We carefully address potential omitted variable bias through the rich set of fixed effects (in the next subsection, we provide more results with an even richer set of control variables and fixed effects). Especially when using the FBP and BBP measures, we can filter out the variation at the bank-date level, the fund-date, and bank-fund level to focus on the time dimension of bargaining power measures at the bank-fund (or family)-date level. The bank-date fixed effects control for time-varying demand factors that could affect pricing, such as the total demand for unsecured funding by a bank at any given date, the number of counterparties the bank deals with and the market share of the bank, among others. Similarly, fund-date fixed effects control for time-varying supply factors, such as the total unsecured lending by a fund at any given date, the number of counterparties or the market share of the fund. Bank-fund fixed effects control for any unobserved factor in the relationship affecting prices. Simultaneity bias could in turn arise due to prices simultaneously affecting market shares (FBP and/or BBP). We provide additional robustness checks varying the time period in our market share / bargaining power variables in the Internet Appendix, which yield very similar results. It is important to stress that individual contracts have a negligible effect on our market share and bargaining power measures. After controlling for date-instrument fixed effects that capture time variation in market prices for a given funding instrument, any simultaneity bias stemming from new contracts between a fund and a bank in a given period are unlikely to have a discernible and meaningful impact. Accordingly, our market / bargaining power measures for a given bank and fund exhibit very little variation over time – with the exception of the MMF reform. Our results with bank-fund fixed effects suggest that such small variations can have a significant price effects.

C. *Pricing of unsecured versus repo funding after the US MMF reform*

In this subsection, we leverage the joint impact of the reform on unsecured and repo markets to further tighten the identification of the effect of the variables of interest. An implication of the reform is that as the supply of unsecured funding became scarce, the repo market saw an increase in the supply of funding. Many prime funds were converted into government or Treasury funds which can provide repo funding to banks, but not unsecured funding. Due to increased outside options of banks, funds' bargaining power in the repo market should thus be lower in the post-reform period. We run the following regression to test this conjecture:

$$\begin{aligned} Rate_{bfct} = \beta_1 X + \beta_2 \mathbb{1}(Repo_{bfct}) * X + \beta_3 \mathbb{1}(Post_t) * X + \beta_4 \mathbb{1}(Post_t) * \mathbb{1}(Repo_{bfct}) * X \\ + Controls + FixedEffects + \epsilon_{bfct} \end{aligned} \tag{9}$$

where we replace X by MS^s_{ft}, $MS^s_{f^*t}$, FBP_{bft} , and $FBP^s_{bf^*t}$ in different specifications as shown in Table IV. As before, the sample contains observations in 2015 as the "pre-period" and between October 2016 and March 2017 (both included) as the "post-period." January 2016 - September 2016 corresponds to the reform implementation period and observations between those dates are omitted. Controls in all columns include $Log(value_{bfct})$, $Rem.maturity_{bfct}$, $RelLength^s_{bft}$, $RelLength^s_{bf^*t}$, $TotVolume^s_{bft}$, and $TotVolume^s_{bf^*t}$ as well as the interaction of all these variables with $\mathbb{1}(Repo_{bfct})$, which is a dummy variable indicating whether the contract is a repo. In addition, in columns (5) and (7), we also include BBP_{bft} and its interaction with $\mathbb{1}(Repo_{bfct})$. In columns (6) and (8), we include BBP_{bf^*t} and its interaction with $\mathbb{1}(Repo_{bfct})$. We also include a very rich set of fixed effects, $Bank * Date * Instrument$ and $Bank * Fund * Instrument$ fixed effects in all columns, and in addition we use $Fund * Date * Instrument$ fixed effects in columns (5)-(8), where the variable of interest is FBP instead of MS. These rich set of controls – especially the fixed effects – absorb a lot of the variation, helping us to tightly identify the parameters of interest.

In all regressions, our hypothesis is $\beta_3 > 0$ and $\beta_4 < 0$, so that post-reform bargaining power of funds is greater in the unsecured segment, while it is lower in the repo segment. We present the results in Table IV. In columns (1)-(4), in addition to the control variables explained above,

Table IV

Comparing unsecured funding and repo pricing around the US MMF reform

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Funds:	All	All	Prime	Prime	All	All	Prime	Prime
Measure:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
MS^s_{ft}	-1.86**		-1.86**					
	(0.79)		(0.80)					
$\mathbb{1}(Repo_{bfct}) * MS^s_{ft}$	1.95**		2.62***					
	(0.83)		(0.91)					
$\mathbb{1}(Post_t) * MS^s_{ft}$	1.75***		1.75***					
	(0.64)		(0.64)					
$\mathbb{1}(Post_t) * MS^s_{ft} * \mathbb{1}(Repo_{bfct})$	-1.51**		1.29					
	(0.69)		(1.32)					
MS^s_{f*t}		-0.83***		-0.83***				
		(0.29)		(0.29)				
$\mathbb{1}(Repo_{bfct}) * MS^s_{f*t}$		0.96***		0.95***				
		(0.31)		(0.34)				
$\mathbb{1}(Post_t) * MS^s_{f*t}$		0.86***		0.86***				
		(0.29)		(0.29)				
$\mathbb{1}(Post_t) * MS^s_{f*t} * \mathbb{1}(Repo_{bfct})$		-1.01***		-0.93***				
		(0.29)		(0.31)				
FBP^s_{bft}					-0.02		-0.02	
					(0.03)		(0.03)	
$\mathbb{1}(Repo_{bfct}) * FBP^s_{bft}$					0.03		0.13***	
					(0.04)		(0.05)	
$\mathbb{1}(Post_t) * FBP^s_{bft}$					0.07**		0.07**	
					(0.03)		(0.03)	
$\mathbb{1}(Post_t) * FBP^s_{bft} * \mathbb{1}(Repo_{bfct})$					-0.06		-0.57*	
					(0.06)		(0.33)	
FBP^s_{bf*t}						0.02		0.00
						(0.02)		(0.02)
$\mathbb{1}(Repo_{bfct}) * FBP^s_{bf*t}$						0.03		0.03
						(0.04)		(0.06)
$\mathbb{1}(Post_t) * FBP^s_{bf*t}$						0.09***		0.09***
						(0.03)		(0.03)
$\mathbb{1}(Post_t) * FBP^s_{bf*t} * \mathbb{1}(Repo_{bfct})$						-0.14***		-0.19*
						(0.04)		(0.10)
Observations	105,397	105,397	83,377	83,377	103,882	103,882	82,102	82,102
R-squared	0.92	0.92	0.92	0.92	0.94	0.94	0.94	0.94
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Bank*Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank*Fund*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Fund*Date*Instrument FE					✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest rate (in basis points). Columns (1), (2), (5), and (6) include unsecured and repo contracts by all types of funds. Columns (3), (4), (7), and (8) include unsecured and repo contracts, but only by prime funds. The sample contains observations in 2015 as the "pre-period" and between October 2016 and March 2017 (both included) as the "post-period." January 2016 - September 2016 corresponds to the reform implementation period and observations between those dates are omitted. MS^s_{ft}, MS^s_{f*t}, FBP_{bft} , and FBP^s_{bf*t} are the market share of the fund, the market share of the fund family, the share of a given fund in the borrowing of a given bank, and the share of a given fund family in the borrowing of a given bank in the relevant segment (repo or unsecured funding), respectively. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 – the implementation date of the reform. Controls in all columns include $Log(value_{bfct})$, $Rem.maturity_{bfct}$, $RelLength^s_{bft}$, $RelLength^s_{bf*t}$, $TotVolume^s_{bft}$, and $TotVolume^s_{bf*t}$ as well as the interaction of all these variables with $\mathbb{1}(Repo_{bfct})$. In addition, in columns (5) and (7), we also include BBP_bft and its interaction with $\mathbb{1}(Repo_{bfct})$. In columns (6) and (8), we include BBP_bf*t and its interaction with $\mathbb{1}(Repo_{bfct})$ We include fixed effects indicated by ✓. Standard errors clustered at the fund level are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

we also include $Date * Instrument$, $Bank * Date$, and $Fund * Instrument$ fixed effects. We show that indeed in all specifications the coefficient on $\mathbb{1}(Post_t) * X$ is positive and significant, whereas that on $\mathbb{1}(Post_t) * \mathbb{1}(Repo_{bfct}) * X$ is negative and significant, for each different specification with $X \in \{MS^s_{ft}, MS^s_{f*t}, FBP_{bft}, FBP^s_{bf*t}\}$.

We argue that our identification of these coefficients is cleanest in columns (3) and (4) for the market share measures and in columns (7) and (8) for the fund bargaining power measures. In these columns, we only focus on prime funds. The advantage of this exercise is twofold. First, unlike government or Treasury funds, prime funds can provide both repo and unsecured funding. Hence, we can show that the bargaining power of the same fund is different across unsecured and repo funding. Second, prime funds that remained in the market after the reform face competition by newly established government funds. Therefore, arguably they are the more suitable group to test the impact of our measures rather than the whole market.

Taken together, all results are in line with our hypotheses about the impact of market frictions on pricing. Reduced outside options in unsecured funding markets led to an increase in the relative bargaining power of funds after the reform, whereas on the flip side, increased outside options of banks in repo markets led to a decrease in the relative bargaining power of funds in those markets.

V. Heterogeneous dollar funding demand, market frictions and regulation

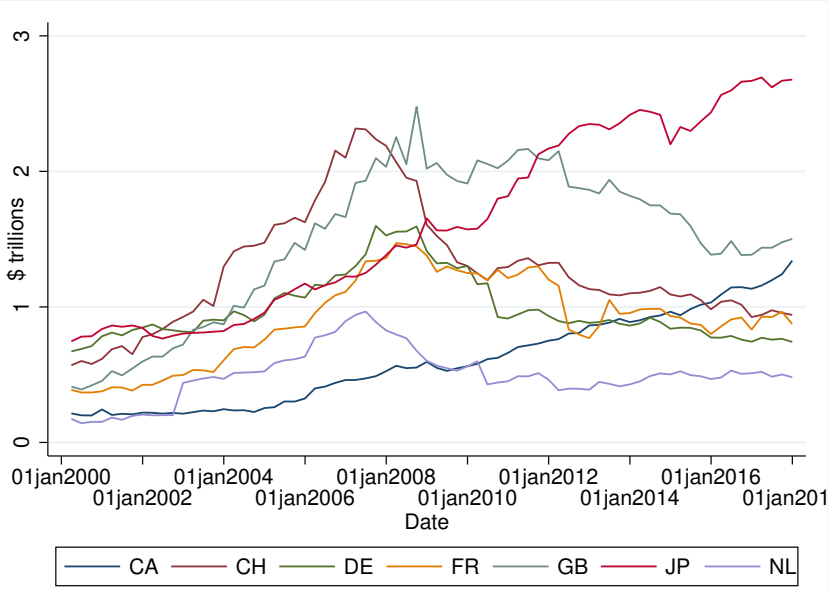
Having analyzed an exogenous funding supply shock, we now turn to the demand side of dollar funding and look at both unsecured and secured funding. To set the stage for the identification strategies we develop below, we first show that the dollar demand profiles of banks are increasingly heterogeneous. Next, we combine this with the OTC market frictions identified previously and present two additional ways to identify market/bargaining power as determinants of pricing. The first one focuses on the pricing of unsecured contracts between Japanese banks and US MMFs using the US MMF reform as an event study. The second one shows the impact of quarter-end window dressing by European banks on repo markets, providing a causal interpretation of the impact of competition on repo pricing. Finally, we exploit the quarter-end effects further and look at the incentives for regulatory arbitrage in repo markets due to differential implementation of post-GFC

banking regulations. We show suggestive evidence that these arbitrage activities – reflected in quarter-end repo window-dressing – lead to spillovers to another key market for dollar funding – the FX swap market.

A. Heterogeneous balance sheets of non-US global banks

The growing divergence in global banks' business models has implications for dollar funding demand profiles, which we leverage for our identification strategy of market/bargaining power.[22] Data on their consolidated dollar assets at the global level show that European banks have reduced their dollar banking activities, whereas Japanese and Canadian banks' kept increasing.

Figure 5
Global dollar assets: Rise of Japanese and Canadian banks, and decline of European



Note: The legend refers to bank nationalities. CA = Canada, CH = Switzerland, DE = Germany, FR = France, GB = United Kingdom, JP = Japan, NL = Netherlands. Inter-office positions are excluded.

Source: BIS consolidated banking statistics and locational banking statistics by nationality; authors' calculations.

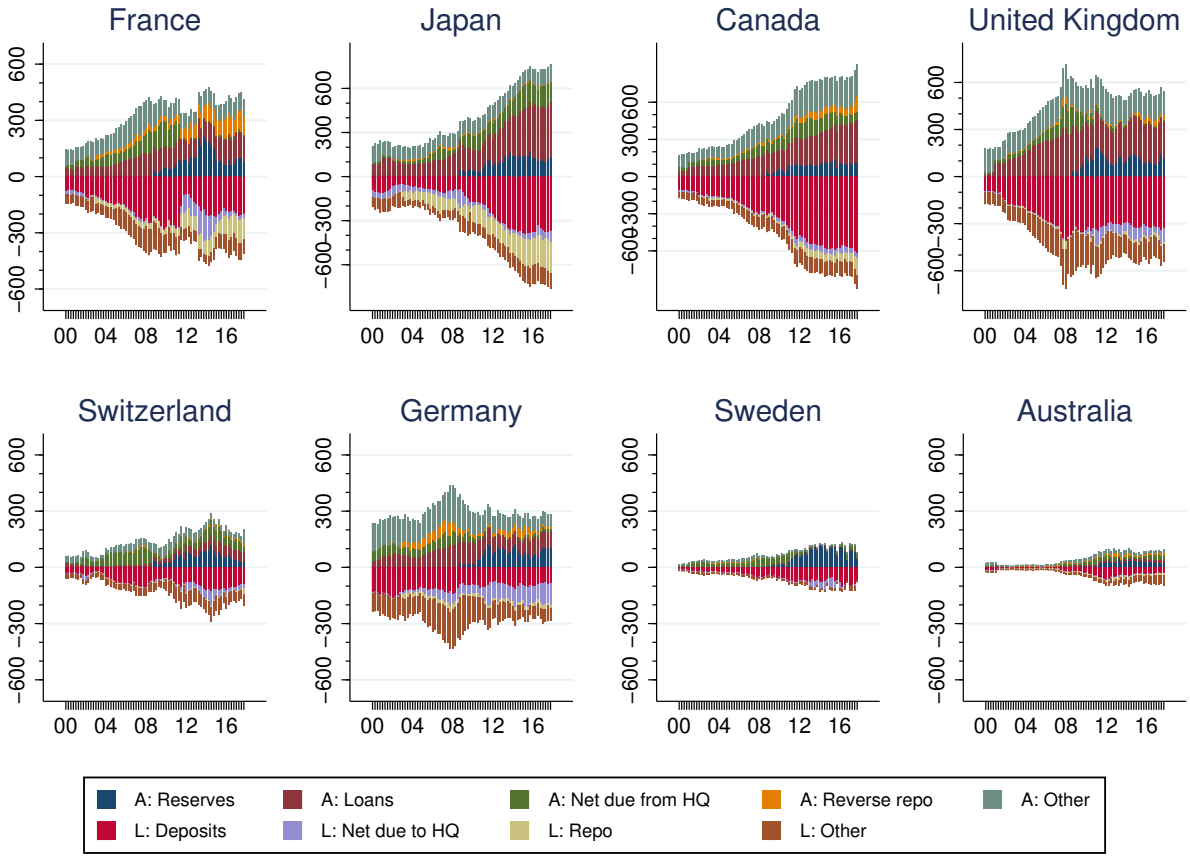
Divergence occurred not only in terms of size, but also composition. There has been a drastic change in the sources and uses of dollars by non-US global banks.[23] The regulatory filings of the

[22]The analysis is done at the level of bank nationalities, i.e. Japanese banks, Canadian banks, etc., for two main reasons. Banks headquartered in the same country face similar regulatory regimes, which does lead to similar business models in many cases. Moreover, focusing on bank nationalities allows for a better comparison of our results with dollar funding costs as implied by the cross-currency basis across different currencies – a feature we address in the next section.

[23]The divergence between these bank nationalities could be attributed to several factors, such as the eurozone

US affiliates of non-US banks provide rich information on how these banks changed their business models since the GFC. US affiliates play a key role in funding and conducting dollar operations, due to their easier access to wholesale dollar funding markets. We document the full view of balance sheets aggregated at the bank nationality level in Figure 6. Similar to the patterns in Figure 5, Japanese and Canadian banks also increased their activities in the United States, while European banks' size never fully recovered from the GFC and the eurozone crisis.

Figure 6
"Unpacking" the balance sheets of US affiliates of non-US global banks
By bank nationality (in $ billions)



Note: Positive numbers refer to assets (A) and negative numbers refer to liabilities (L).
Source: US Call reports (FFIEC 002, FFIEC 031/041, FR 2886b); authors' calculations.

Three main differences stand out. First, there is a notable contrast regarding the importance

crisis, different levels of interest rates (hence the attractiveness of dollar banking) and differences in bank supervision, among others. This paper takes the divergence as given. Our focus is on the implications of this for the price of dollar funding and other market power-related frictions when obtaining dollars from US MMFs.

of bank loans, which tend to be longer-term assets. While the loan books of all banks prior to 2011 showed relatively similar patterns, those of Japanese bank branches in the US increased massively relative to others since 2011. Second, banks of some nationalities – notably France and Canada – became very large repo intermediaries. This is in stark contrast with Japanese banks, which stand out for being very large and unique players that use repo markets in the United States for funding and not for intermediation. Third, after 2011 most European banks massively shifted their activities towards short-term arbitraging of interest on excess reserves (IOER). French, UK, and German banks received net liquidity from related non-US offices (mostly their headquarters), while Swiss and Swedish banks borrowed short-term unsecured funding to invest in interest paying reserves (see also Banegas and Tase (2016) for a discussion of this arbitrage). In the Internet Appendix, we plot each balance sheet item separately for clearer visibility of their patterns and provide further details on their evolution.

These three differences have implications for dollar funding demand profiles. For one, with a continued focus on a traditional business model centered around maturity transformation and very large dollar loan books, Japanese banks have a stronger demand for more longer maturity funding, which is obtained through unsecured funding instruments rather than repos.[24] Banks from other nationalities that shifted their business models toward short-term arbitrage such as repo intermediation and IOER arbitrage, in turn, are likely to be more responsive to short-term profit opportunities. Such opportunities can arise by a combination of market structure, the dollar demand profiles of various banks, and regulation.

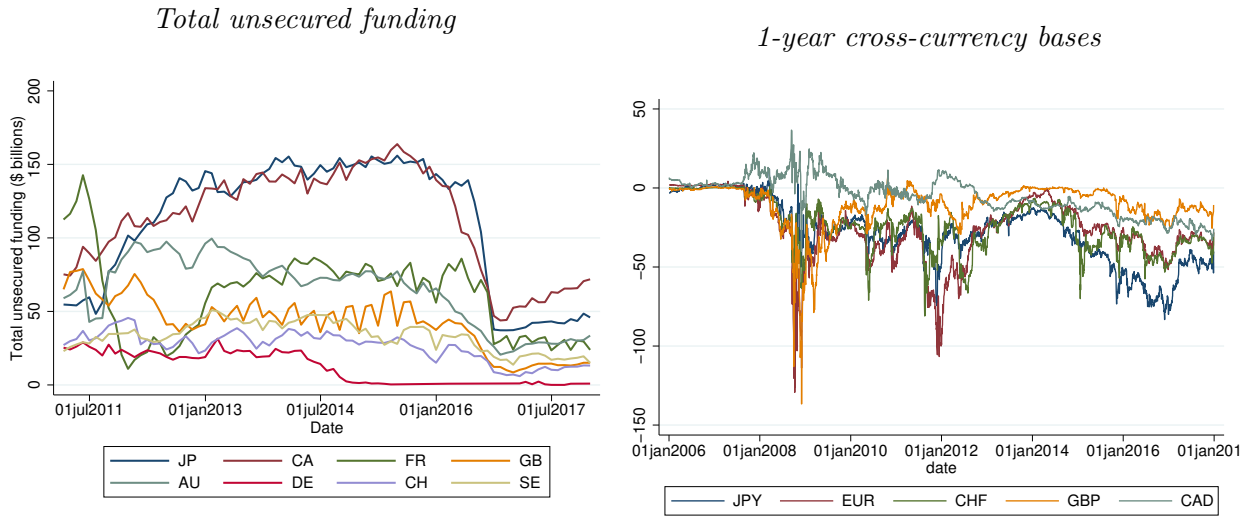
B. The price of unsecured dollar funding: the case of Japanese banks

First, we study Japanese banks and the impact of the US MMF reform on the pricing of their unsecured contracts. Japanese banks, together with Canadian banks, were the largest recipients of unsecured funding through prime funds prior to the reform, reflecting the increase in their balance sheets. In the left-hand panel of Figure 7, we show that these banks were affected the most by the reform. At the same time, dollar funding costs measured by the cross-currency basis indicate that the JPY/USD basis widened more than that of other currencies – indicating heightened dollar

[24]Indeed, their weighted average maturity in borrowing from MMFs is the largest in our sample.

funding demand by Japanese entities, including banks.[25]

Figure 7
Total unsecured funding by bank nationality and cross-currency bases



Notes: The legend in the left-hand panel refers to bank nationalities; AU = Australia, CA = Canada, CH = Switzerland, DE = Germany, FR = France, GB = United Kingdom, JP = Japan, NL = Netherlands, SE = Sweden. The legend in the right-hand panel refers to currencies; JPY = Japanese yen, EUR = euro, CHF = Swiss franc, GBP = British pound, CAD = Canadian dollar.

Sources: Bloomberg; Crane data; authors' calculations.

As documented above, Japanese banks tend to have more longer-term dollar assets (i.e. loans). Moreover, they tend to have more limited access to core deposits compared to others, for example Canadian banks (which we discuss below). As a result, Japanese banks were more pressed to roll over MMF funding after the reform, relative to other banks with more short-term assets that instead could (and did) scale back operations (such as the IOER arbitrage) or could more easily substitute MMF funding. The overall rise of dollar funding costs as measured by the cross-currency basis serves as an indication of this.

Based on these arguments, we test whether our measures of market/bargaining power led to a larger change in prices for Japanese banks compared to others in the aftermath of the MMF reform. We use the following specification:

[25] Canadian banks have a large dollar deposit base and business models that feature less maturity transformation than Japanese banks as shown in Section V.A. This is in part reflected by a more modest widening of the cross-currency basis compared to other currencies.

$$Rate_{bfct} = \kappa_1 \mathbb{1}(JP_b) * MS_{ft} + \kappa_2 \mathbb{1}(JP_b) * \mathbb{1}(Post_t) * MS_{ft}$$
$$+ K_3 X_{bfct} + \eta_{t,inst(c)} + \eta_{bt} + \eta_{ft} + \epsilon_{bfct} \quad (10)$$

where the naming convention of variables is as above, and $\mathbb{1}(JP_b)$ is a dummy equal to 1 if bank b is headquartered in Japan. We test whether the market share of a fund (or family) has a larger impact on the pricing of unsecured funding for Japanese banks. We expect the coefficient κ_2 to be positive, as we expect the demand for this type of funding to be less elastic for Japanese banks compared to others.

As in the previous sections, we also report results using the bargaining power variables FBP and BBP measured both at the fund (f) and fund family (f^*) level, together with a rich set of control variables and fixed effects to strip out potential confounding factors:

$$Rate_{bfct} = \delta_1 BBP_{bft} + \delta_2 FBP_{bft} + \delta_3 \mathbb{1}(JP_b) * FBP_{bft} + \delta_4 FBP_{bft} * \mathbb{1}(Post_t)$$
$$+ \delta_5 \mathbb{1}(JP_b) * FBP_{bft} * \mathbb{1}(Post_t) + \Delta_6 X_{bfct} + \eta_{t,inst(c)} + \eta_{bt} + \eta_{ft} + \epsilon_{bfct} \quad (11)$$

Given our results in Section IV, we focus on the interactions of the FBP measures only and use the BBP measure as a control variable. Our hypothesis in these specifications is that δ_5 is positive: funds or families could charge a higher price to Japanese banks in the aftermath of the reform, if they command a greater share of the borrowing of Japanese banks compared to others. This reflects lower outside options (for example, due to a wider cross-currency basis) or more broadly a less elastic demand by Japanese banks relative to others.

In all specifications we use the same controls as in Equation (7) and Equation (8), switching controls at the bank-fund-date level to measures at bank-fund family-date level depending on the specification. In particular, we always include fixed effects at the bank-date, fund-date and instrument-date level, to control for time-varying demand and supply factors as well as aggregate factors that affect pricing of instruments on average. Note that our fixed effects also account for all individual and double-interaction terms of all variables that are in the triple interaction.

Table V

The US MMF reform and the pricing of unsecured funding for Japanese and Canadian banks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Measure:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
Bank nationality:		$\mathbb{1}(X_b) \equiv \mathbb{1}(JP_b)$				$\mathbb{1}(X_b) \equiv \mathbb{1}(CA_b)$		
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
$\mathbb{1}(X_b) * MS_{ft}$	-0.08				-0.08			
	(0.14)				(0.07)			
$\mathbb{1}(X_b) * MS_{ft} * \mathbb{1}(Post_t)$	0.32				0.02			
	(0.45)				(0.12)			
$\mathbb{1}(X_b) * MS_{f^*t}$		0.05				-0.03		
		(0.09)				(0.03)		
$\mathbb{1}(X_b) * MS_{f^*t} * \mathbb{1}(Post_t)$		0.38*				-0.02		
		(0.19)				(0.07)		
BBP_{bft}			-0.04				-0.04	
			(0.04)				(0.04)	
FBP_{bft}			0.02				0.01	
			0.03)				(0.03)	
$\mathbb{1}(X_b) * FBP_{bft}$			-0.11				-0.02	
			(0.08)				(0.09)	
$FBP_{bft} * \mathbb{1}(Post_t)$			0.12				0.14	
			(0.09)				(0.09)	
$\mathbb{1}(X_b) * FBP_{bft} * \mathbb{1}(Post_t)$			0.22				0.05	
			(0.20)				(0.11)	
BBP_{bf^*t}				-0.03				-0.02
				(0.05)				(0.05)
FBP_{bf^*t}				0.07***				0.07***
				(0.02)				(0.02)
$\mathbb{1}(X_b) * FBP_{bf^*t}$				0.04				0.03
				(0.05)				(0.03)
$FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.07				0.09*
				(0.06)				(0.05)
$\mathbb{1}(X_b) * FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.30**				0.02
				(0.12)				(0.05)
Observations	59,568	59,568	59,568	59,568	59,568	59,568	59,568	59,568
R-squared	0.91	0.91	0.91	0.91	0.91	0.91	0.91	0.91
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Fund*Date FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank*Date FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank b when borrowing from a fund. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and March 2017 (both included) as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(X_b)$ is a dummy variable that is one if the bank is headquartered in Japan ($\mathbb{1}(JP_b)$) in columns (1) through (4), and it is a dummy variable that is one if the bank is headquartered in Canada ($\mathbb{1}(CA_b)$) in columns (5) through (8). $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 – the implementation date of the reform. Controls include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

The first four columns of Table V present the results. The coefficients of the triple interaction terms are positive, in line with our hypotheses. Furthermore, our results are stronger with measures at the fund family level. An increase in the market/bargaining power of a fund family leads to higher prices for Japanese banks compared to others in the aftermath of the reform (relative to the pre-reform period). Moreover, results remain similar when we vary the sample period, as we show in the Internet Appendix.[26]

While Canadian banks also lost a significant amount of dollar funding from prime funds, similar to Japanese banks, our prior is that there should not be a similar price effect for two reasons: Compared to Japanese banks, Canadian banks have access to a broader dollar deposit base given their proximity to the United States and also due to the fact that their operations there are mainly based on subsidiaries rather than branches (see the Internet Appendix D for details). Subsidiaries can take retail deposits from US residents, while branches are essentially limited to wholesale funding or cross-border dollar funding. Furthermore, in line with our prior, the CAD/USD FX swap basis remained stable compared to other major currencies during the implementation of the reform. In the last four columns of Table V, we repeat the same analysis, but instead of a triple interaction with a dummy variable indicating whether a bank is headquartered in Japan, we use a dummy variable indicating whether a bank is headquartered in Canada. As these columns show, MMFs did not charge additional markups to Canadian banks as they did to Japanese banks after the reform.

C. European banks' window-dressing at quarter-ends and repo pricing

We now turn to the repo market to identify market/bargaining power for secured funding instruments. Our strategy combines the growth in the repo intermediation books of banks from some nationalities (notably French) with the timing of post-GFC regulations and institutional characteristics of US repo markets, in order to identify changes in outside options of both MMFs and banks.

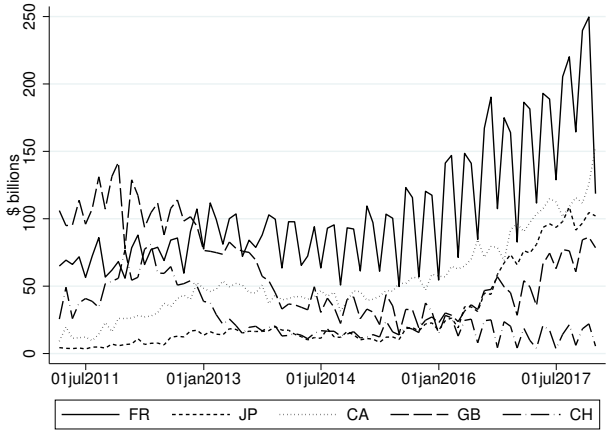
The first building block of our identification strategy is the heterogeneous implementation of Basel III regulations across jurisdictions. For European banks, the implementation of the leverage

[26]The results are stronger when we use shorter periods around the implementation of the reform, since with time banks can and do substitute into other sources of funding (Aldasoro, Balke, Barth, and Eren (2019)).

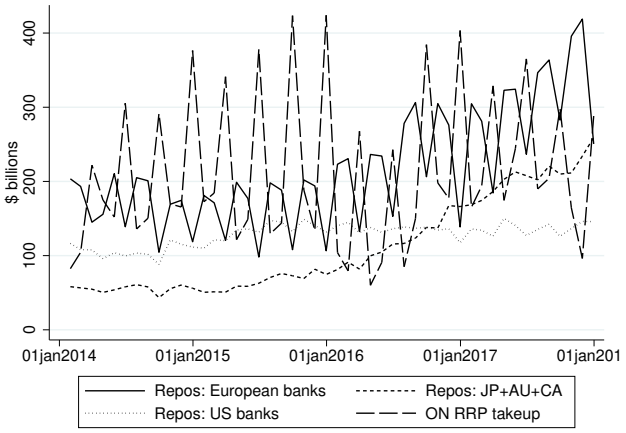
ratio in particular is less strict than for banks from other countries (Munyan (2015), CGFS (2017)). Concretely, the former can report their leverage based on a quarter-end snapshot of their balance sheet, as opposed to a measure based on the daily average of the balance sheet over the entire quarter. This leads to a more pronounced quarter-end window dressing for European banks, in particular French banks (see Figure 8).[27] Some of these banks "window-dress" their balance sheets: they substantially expand their balance sheets within quarters, particularly repo positions, and then rapidly unwind them at quarter-end regulatory reporting dates, as illustrated in Figure 8, to reduce their reported leverage ratio.[28]

Figure 8
Banks' repo volumes and MMF take-up of ON RRP

Repo volumes drop at quarter-ends (by bank nationality)



ON RRP takeup rises as repo volumes drop



Notes: With the exception of "ON RRP takeup" in the right-hand panel (which refers to takeup of the Federal Reserve overnight repurchase facility), acronyms in legends refer to bank nationalities; AU = Australia, CA = Canada, CH = Switzerland, FR = France, GB = United Kingdom, JP = Japan, US = United States.
Sources: Crane data; OFR MMF monitor; authors' calculations.

Our identification strategy relies on the following. As some European banks shrink their repo positions at quarter-ends, we argue MMFs temporarily see their bargaining power vis-à-vis other banks reduced, i.e. the temporary withdrawal of regular counterparties reduces MMFs' outside options.[29] Window-dressing banks return to repo markets soon after the end of the quarter, as

[27]The large window-dressing by French banks is due to the fact that they have the largest matched repo books among European banks. The reasons for why French banks, and not other European banks, focus on this line of business is beyond the scope of this paper.

[28]Note that this unwinding is the most pronounced for French banks. For Japanese and Canadian banks there is little change between quarter-ends and other month-ends.

[29]We argue that the decision of how much to withdraw from repo markets by European banks is taken at headquar-

shown by Munyan (2015), improving the outside options of MMFs in non-quarter-end periods. We therefore conjecture that the price of repo funding for non-European banks is reduced at quarter-ends.[30]

Key to our identification strategy is the existence of an exception to the limited outside options of MMFs at quarter ends. In particular, since September 2013 MMFs can use the overnight reverse repo (ON RRP) facility to park their cash at the Federal Reserve in exchange for US Treasury collateral (see the right-hand panel of Figure 8 and Aldasoro, Ehlers, and Eren (2017a)). Therefore, our conjecture that the price non-European banks pay for their repos is smaller at quarter ends *should not* apply for overnight repos with US Treasury collateral. If anything, a higher price for these contracts would also be possible and would indicate that MMF bargaining power vis-à-vis banks for overnight Treasury repos is increased thanks to the credible outside option given by the ON RRP.

Finally, we also rely on the timing of regulatory changes to aid identification. As noted earlier, the ON RRP became available to MMFs starting in September 2013. But we also make use of the timing of Basel III regulations: banks have a public disclosure requirement of the leverage ratio since January 2015. We expect, overall, that the reduction in prices for non-European banks at quarter-ends is more pronounced after 2015 since the window-dressing of European banks increased thereafter. Moreover, we expect the prices for overnight Treasuries to be higher at quarter-ends compared to other months especially since September 2013 since the Federal Reserve became a counterparty to MMFs from that date onwards.

Taking these elements together, we expect that: (i) MMF bargaining power is reduced at quarter-ends and non-European banks accordingly pay less for repo funding on these dates; (ii) this effect strengthens after leverage ratio public disclosures become effective in January 2015; (iii) and the effect is weaker or even non-existent for overnight repos with Treasury collateral, given the outside option available to MMFs since September 2013. Table VI presents our findings.

Our results confirm the relevance of market / bargaining power also for secured funding. In columns (1)-(3), we show that non-European banks receive favorable repo pricing at quarter-ends

ters, depending on regulatory ratio calculations at a consolidated level at each quarter-end and hence is exogenous to MMFs and other banks.

[30]Quarter-end window-dressing effects are observed in the repo segment and are not much of a concern in the unsecured segment as the implementation of the leverage ratio impacts primarily the repo market. See CGFS (2017) for details.

Table VI
Identification of market/bargaining power in the repo market

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Segment:	Repo	Repo	Repo	Repo	Repo	Repo	Repo
Banks:	All	All exc. UK, CH	All exc. US	All	All	All	All
Instruments:	All	All	All	All	All exc. ON/T	ON/T	ON/T
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
$\mathbb{1}(nonEU_b)$	1.06***	1.27***	1.50***	0.53*	0.67**	-0.40***	-0.54***
	(0.23)	(0.22)	(0.39)	(0.27)	(0.31)	(0.09)	(0.16)
$\mathbb{1}(nonEU_b)$	-0.70***	-0.63***	-1.55***	-0.47***	-0.65***	0.88***	0.10
$*\mathbb{1}(QE_t)$	(0.14)	(0.14)	(0.19)	(0.17)	(0.18)	(0.25)	(0.37)
$\mathbb{1}(nonEU_b)$				1.18***	1.52***		
$*\mathbb{1}(t \geq Jan2015)$				(0.31)	(0.36)		
$\mathbb{1}(nonEU_b)$				-0.48**	-0.63**		
$*\mathbb{1}(QE_t) * \mathbb{1}(t \geq Jan2015)$				(0.24)	(0.27)		
$\mathbb{1}(nonEU_b)$							0.16
$*\mathbb{1}(t \geq Sep2013)$							(0.19)
$\mathbb{1}(nonEU_b)$							0.76
$*\mathbb{1}(QE_t) * \mathbb{1}(t \geq Sep2013)$							(0.46)
Observations	180,638	145,010	117,432	180,638	154,184	16,212	24,560
R-squared	0.92	0.92	0.93	0.92	0.91	0.99	0.99
Controls	✓	✓	✓	✓	✓	✓	✓
Date*Collateral FE	✓	✓	✓	✓	✓		
Date*Fund FE	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank when borrowing from a fund. All regressions refer to repo contracts. The full sample includes banks from the United States, Canada, Japan, France, Switzerland, the United Kingdom, Germany, the Netherlands and Australia. $\mathbb{1}(nonEU_b)$ is a dummy variable equal to 1 if the bank is from Japan, Canada, the United States or Australia. $\mathbb{1}(QE_t)$ is a dummy variable for quarter-ends. $\mathbb{1}(t \geq Sep2013)$ and $\mathbb{1}(t \geq Jan2015)$ are dummy variables if the month is after (and including) September 2013 (first use of the ON RRP facility) and January 2015 (public disclosure requirements for Basel III regulations). Controls include $Log(value_{bfct})$, $5yCDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ in all columns where appropriate, ie.maturity is excluded in the last two columns as we only focus on overnight maturities. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

(i.e. when European banks retreat), compared to other months when all banks are active and compete for repo funding. In column (1), we compare European banks, i.e. banks from France, Switzerland, the United Kingdom, Germany and the Netherlands, with banks from the United States, Canada, Japan and Australia. In column (2), we exclude Switzerland and the United Kingdom from the sample since – while exhibiting quarter-end contractions – they are not always subject to the same way of implementing regulations as other European banks. Nevertheless, the results are similar. When we exclude US banks, in column (3), results also remain consistent and, if anything, get somewhat stronger. In columns (4) and (5), we explore whether the implementation of the public disclosure requirements of Basel III regulations intensified these pricing patterns. In

column (4), we look at the entire repo segment and in column (5) we omit overnight repos with Treasury collateral. In both columns, the results are similar. After January 2015, non-European banks pay a significantly higher price on months that are not quarter-ends. At post-2015 quarter-ends, the price discount that non-European banks get is larger. Finally, in the last columns we show that the presence of the Fed in the overnight Treasury repo market results in a larger bargaining power for MMFs and hence higher prices for repos with US Treasury collateral (column 5). The coefficients on the last column are in line with our hypothesis that this effect intensifies after the first use of the facility, though this result is not statistically significant.

D. Spillovers of quarter-end repo disruptions into FX swaps

Finally, in this section we study whether frictions in the market of dollar funding from US MMFs to non-US banks may have wider implications for dollar funding markets in general. In particular, our results suggest there might be spillovers from the repo market to the FX swap market. We take the findings in this section as suggestive evidence, as the sample size underlying the analysis is small.

As discussed earlier, European – especially French – banks reduce their repos at quarter-ends to improve their regulatory ratios. At the same time, French banks have substantial matched repo books, i.e. they are repo intermediaries (see Figure 13). Japanese banks, on the other hand, are very large net repo borrowers. So large in fact, that US MMFs can only provide a small fraction of the repo funding needs of Japanese banks.[31]

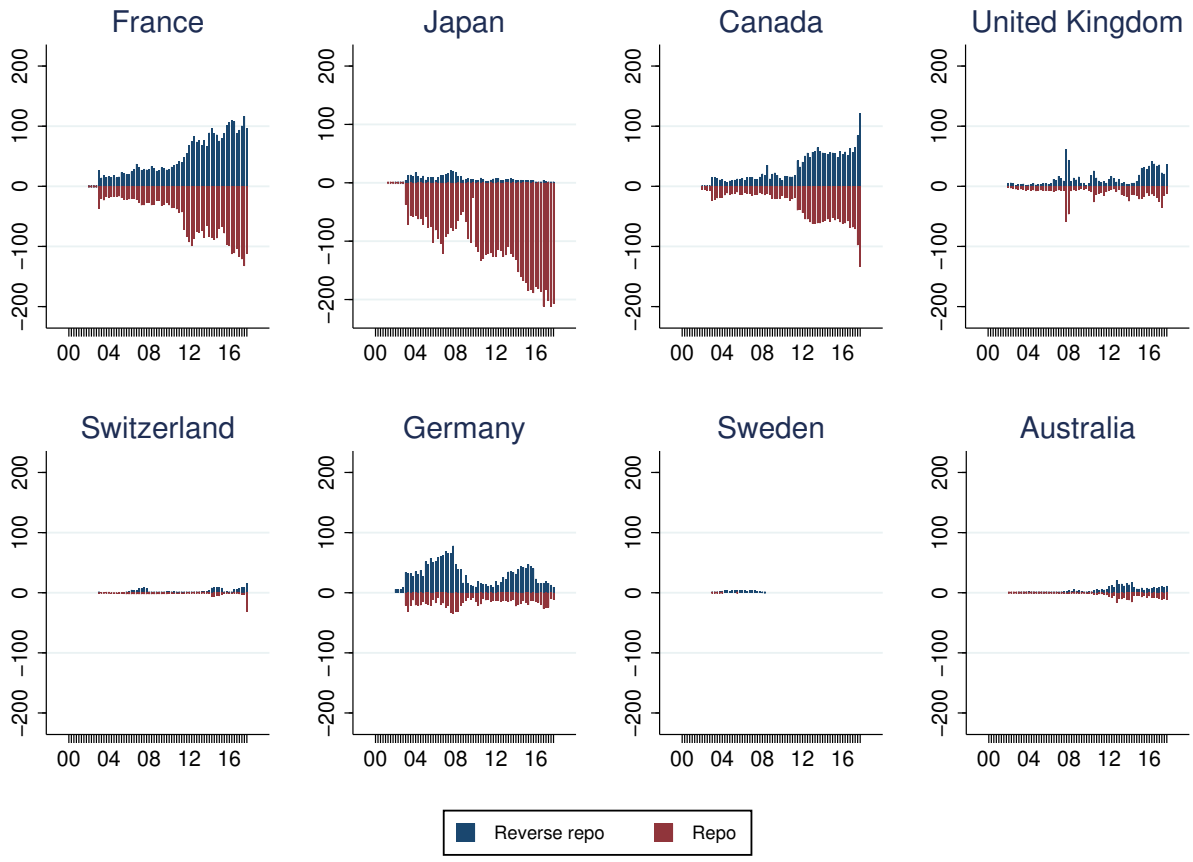
We conjecture that French banks intermediate repos to Japanese banks. If the latter rely on repo intermediation by other banks to obtain dollar funding, the quarter-end contractions in repo markets reduce the supply of overall dollar funding available to them. If this is the case, Japanese banks are pressed to find alternative dollar funding sources at quarter-ends.[32]

As repos are generally the cheapest source of funding in wholesale markets, we expect disruptions in the repo market to spill over to other markets which are a more expensive source of funding for

[31] This can be seen comparing total repos obtained by MMFs and the outstanding repos reported in the balance sheet.

[32] Even though the timing of the repo contraction is predictable, how much French banks withdraw each quarter is a decision taken at the headquarter level, depending on leverage ratio considerations of the consolidated bank balance sheets. Hence, we argue that the reduction of French repo volume generally is unpredictable and exogenous to Japanese banks.

Figure 9
Repos and reverse repos of US branches and agencies of non-US banks
By bank nationality (in $ billions)



Source: FFIEC 002 filings, authors' calculations.

banks, such as the FX swap market. Moreover, we only expect this spillover for short maturity instruments, as banks use these only to weather through the short-lived negative supply shock in the cheaper repo market around quarter-ends.

We estimate the following specification:

$$\Delta JPY/USD_t^{QE} = \alpha_1 + \alpha_2 \Delta FR\,repo_t^{QE} + \alpha_3 \Delta EUR/USD_t^{QE} + \epsilon_t \tag{12}$$

where $\Delta JPY/USD_t^{QE}$ denotes the change in the JPY/USD cross-currency basis between quarter-end and the month before the quarter-end, and $\Delta FR\,repo_t^{QE}$ denotes the absolute value of the change in repos French banks conduct with MMFs between quarter-end and the month before

the quarter-end. Since it is the absolute value, a higher number means larger contraction in the amount of repos.[33] In addition, we include $\Delta EUR/USD_t^{QE}$ in the regression in order to control for any global shocks in a given quarter, any other quarter-end effect or any effect of regulation that simultaneously affects French repos and the JPY/USD basis.[34]

Table VII shows a statistically and economically significant negative relationship between the changes in repo activities of French banks between a month before quarter-ends to the end of a quarter, and the contemporaneous change in the JPY/USD basis. Overall, the retreat of French banks from repo markets at quarter-ends explains more than 65% of the contemporaneous variation in the 1-week JPY/USD cross-currency basis. An additional $10 billion reduction in repos by French banks widens the 1-week cross-currency basis by 6.5 basis points. For tenors longer than 1-week, this effect is zero, with a low R^2, in line with our hypothesis.[35] We take this as suggestive evidence of dollar intermediation by French banks to Japanese banks (or other Japanese entities active in the FX swap markets).[36] In the Internet Appendix we estimate implied profits from intermediation through maturity and collateral transformation and show that they are economically significant and higher than other potential arbitrage opportunities for non-US global banks, such as the IOER arbitrage.

[33] In the Internet Appendix, we show a scatterplot of the relationship (see Figure 15). The figure shows that the year-ends of 2016 and 2017 were outliers. This is not surprising as year-ends are periods where many other institutions have annual reporting requirements as well. We exclude these two observations from the regressions.

[34] For each tenor of the JPY/USD basis, we include the EUR/USD of the same tenor.

[35] Even though our results for 1-week regressions are statistically significant and it is reassuring that our placebo tests using longer maturities are not significant, it is important to bear in mind that our sample size is not very large due to the relatively short time series available.

[36] In the Internet Appendix, we show that no such effect is present when considering repos by other European banks with quarter-end reporting, and by Canadian banks – the other large repo intermediaries besides French banks.

Table VII
The quarter-end effect on the JPY/USD basis

	(1) 1W	(2) 1W	(3) 3M	(4) 3M	(5) 1Y	(6) 1Y
ΔFR repo	-0.80***	-0.65***	-0.02	0.03	0.06	0.05
	(0.16)	(0.20)	(0.12)	(0.09)	(0.06)	(0.05)
$\Delta EUR/USD$ *basis* (1W)		0.48*				
		(0.27)				
$\Delta EUR/USD$ *basis* (3M)				0.58***		
				(0.18)		
$\Delta EUR/USD$ *basis* (1Y)						0.33*
						(0.20)
Observations	23	23	23	23	23	23
R-squared	0.65	0.71	0.00	0.36	0.05	0.27

Notes: Bootstrapped standard errors (from 1,000 replications) are in parentheses. ***, **, * denote significance at the 10, 5 and 1% level respectively. 1W, 3M and 1Y refer to the contemporaneous changes in the 1-week, 3-month and 1-year, respectively. The dependent variable is the change in the JPY/USD basis at different maturities. ΔFR repo stands for the (absolute value of) changes in repos with MMFs done by French banks. The control $\Delta EUR/USD$ *basis* is constructed in the same manner as the dependent variable and has the same tenor as the dependent variable for each column. Changes are computed as $month_{quarter-end} - month_{quarter-end-1}$ (the absolute value is taken for changes in French banks' repos with MMFs (in $billions)). The sample runs from December 2011 (Q4 2011) to September 2017 (Q3 2017). The outlier observations corresponding to December 2016 and December 2017 are excluded.

VI. Conclusion

Dollar funding markets are central to the functioning of the global financial system. US MMFs are an important liquidity provider of secured and unsecured funding to global banks. While the market connecting MMFs and banks is deep and liquid, we show it is highly concentrated and subject to bargaining frictions typical of OTC markets. Since the GFC, this key market for dollar funding of global banks has undergone substantial changes. For one, the US MMF reform caused a large shift towards government funds that can provide dollar liquidity solely against US government and agency collateral. But global banks have also grown more heterogeneous in their business models – European banks have reduced their dollar books and shortened maturities, while Japanese banks moved in the opposite direction. Finally, post-crisis regulations, in particular the leverage ratio, have been implemented in a heterogeneous way across countries, resulting in some European banks levering up between quarterly reporting dates. These post-GFC changes and trends have brought the underlying market frictions to the fore.

Our results provide empirical evidence of market frictions in international financial markets (Maggiori, 2021). These frictions are of high relevance for policy makers. Increased market power

of MMFs might have adverse effects both in normal times and in times of dollar funding stress. In normal times, a lack of competition might raise the cost of funding for banks and lead to inefficiencies. During a dollar funding stress episode, MMFs might have an incentive to exploit their market power and charge higher prices to banks that need dollars the most. This could affect those banks' creditworthiness and, in turn, their ability to raise other funding, increasing the risk of a more general freeze in funding markets. Furthermore, concentration in the MMF sector might aggravate the possibility and intensity of bank runs compared to a setup with competitive and small players (Corsetti, Dasgupta, Morris, and Shin, 2004).

While our paper does not aim to evaluate post-crisis regulations, our results point to two potential unintended consequences that may reduce their effectiveness. The first is that improving the credit quality of MMF assets has come at the expense of a reduction in competition. This highlights a more general trade-off that policy makers have been facing: improving the soundness of financial markets may have unintended consequences for their functioning. The second is due to the heterogeneous implementation of global banking regulations across jurisdictions. Quarter-end regulatory reporting as opposed to reporting based on daily averages of the Basel III leverage ratio creates a reshuffling of hundreds of billions of dollar banking activity around quarter-ends which may create risks for the financial system. In addition, this has created undue advantages for market participants by opening up possibilities for regulatory arbitrage. As a result, complex and opaque short-term dollar liquidity intermediation networks across markets and jurisdictions have emerged.

Even though these funding interdependencies seem benign during normal times, they represent direct international spillover channels that could come into play in times of stress. In a situation where dollar funding markets freeze, a large number of national central banks may need to provide dollar liquidity to banks in their jurisdiction to prevent a chain of global liquidity shortages. While we deliberately study the market structure in tranquil times to mitigate confounding factors, the Covid-19 crisis provided a useful test of our results and policy conclusions. First, the activation of swap lines and divergence in the price of dollar funding of banks headquartered in jurisdictions with swap lines versus others show the importance of relative bargaining power in this market (Eren, Schrimpf, and Sushko (2020a)). Second, they show the interdependencies between different instruments in a different setting than we study in our paper, namely having access to cheap FX swaps reduces the price of CPs and CDs for banks in jurisdictions with standing swap lines. Finally,

the Covid-19 crisis highlighted that there are still vulnerabilities in the prime MMF sector. Our results could be helpful in informing further potential reforms of the sector.

REFERENCES

Abbassi, Puriya, and Falk Bräuning, 2020, Demand Effects in the FX Forward Market: Micro Evidence from Banks' Dollar Hedging, *The Review of Financial Studies* .

Aldasoro, Iñaki, Florian Balke, Andreas Barth, and Egemen Eren, 2019, Spillovers of funding dry-ups, *BIS Working Paper 810* .

Aldasoro, Iñaki, Torsten Ehlers, and Egemen Eren, 2017a, Can CCPs reduce repo market inefficiencies?, *BIS Quarterly Review* December, 13–14.

Aldasoro, Iñaki, Torsten Ehlers, Egemen Eren, and Robert N. McCauley, 2017b, Non-US banks' global dollar funding grows despite US money market reform, *BIS Quarterly Review* March, 22–23.

Aldasoro, Iñaki, Egemen Eren, and Wenqian Huang, 2021, Dollar funding of non-US banks through Covid-19, *BIS Quarterly Review* .

Anbil, Sriya, and Zeynep Senyuz, 2018, The regulatory and monetary policy nexus in the repo market, *Finance and Economics Discussion Series 2018-027. Washington: Board of Governors of the Federal Reserve System* .

Anderson, Alyssa, Wenxin Du, and Bernd Schlusche, 2021, Arbitrage capital of global banks, *working paper* .

Avdjiev, Stefan, Wenxin Du, Cathérine Koch, and Hyun Song Shin, 2019, The dollar, bank leverage, and deviations from covered interest parity, *American Economic Review: Insights* 1, 193–208.

Baba, Naohiko, Robert N. McCauley, and Srichander Ramaswamy, 2009, US dollar money market funds and non-US banks, *BIS Quarterly Review* March, 65–81.

Banegas, Ayelen, and Manjola Tase, 2016, Reserve balances, the federal funds market and arbitrage in the new regulatory framework, Finance and Economics Discussion Series 2016-079, Board of Governors of the Federal Reserve System.

Bräuning, Falk, and Victoria Ivashina, 2020, Monetary policy and global banking, *The Journal of Finance* 75, 3055–3095.

Bruno, Valentina, and Hyun Song Shin, 2015, Cross-Border Banking and Global Liquidity, *Review of Economic Studies* 82, 535–564.

Cenedese, Gino, Pasquale Della Corte, and Tianyu Wang, 2020, Currency mispricing and dealer balance sheets .

Cetorelli, Nicola, and Linda S Goldberg, 2011, Global Banks and International Shock Transmission: Evidence from the Crisis, *IMF Economic Review* 59, 41–76.

CGFS, 2017, Repo market functioning, CGFS Papers 59, Committee on the Global Financial System.

CGFS, 2020, US dollar funding: an international perspective, *CGFS Papers no 65* .

Chernenko, Sergey, and Adi Sunderam, 2014, Frictions in shadow banking: Evidence from the lending behavior of money market mutual funds, *Review of Financial Studies* 27, 1717–1750.

Correa, Ricardo, Horacio Sapriza, and Andrei Zlate, 2016, Liquidity shocks, dollar funding costs and the bank lending channel during the european sovereign crisis, Working Paper 16-4, Federal Reserve Bank of Boston.

Corsetti, Giancarlo, Amil Dasgupta, Stephen Morris, and Hyun Song Shin, 2004, Does one soros make a difference? a theory of currency crises with large and small traders, *The Review of Economic Studies* 71, 87–113.

Du, Wenxin, Alexander Tepper, and Adrien Verdelhan, 2018, Deviations from covered interest rate parity, *The Journal of Finance* 73, 915–957.

Duffie, Darrell, Nicolae Gârleanu, and Lasse Pedersen, 2005, Over-the-counter markets, *Econometrica* 73, 1815–1847.

Duffie, Darrell, Nicolae Gârleanu, and Lasse Heje Pedersen, 2007, Valuation in over-the-counter markets, *The Review of Financial Studies* 20, 1865–1900.

Elyasiani, Elyas, and Lawrence G. Goldberg, 2004, Relationship lending: A survery of the literature, *Journal of Economics and Business* 56, 315–330.

Eren, Egemen, Andreas Schrimpf, and Vladyslav Sushko, 2020a, Us dollar funding markets during the covid-19 crisis - the international dimension, *BIS Bulletin no.15* .

Eren, Egemen, Andreas Schrimpf, and Vladyslav Sushko, 2020b, Us dollar funding markets during the covid-19 crisis - the money market fund turmoil, *BIS Bulletin no.14* .

Gabaix, Xavier, and Matteo Maggiori, 2015, International Liquidity and Exchange Rate Dynamics, *The Quarterly Journal of Economics* 130, 1369–1420.

Han, Song, and Kleopatra Nikolaou, 2016, Trading relationships in the OTC market for secured claims: Evidence from triparty repos, FEDS Working Paper 2016-64, Federal Reserve Board.

Hu, Grace Xing, Jun Pan, and Jiang Wang, 2015, Tri-party repo pricing, Working paper 21502, NBER.

Iida, Tomoyuki, Takeshi Kimura, and Nao Sudo, 2018, Deviations from covered interest rate parity and the dollar funding of global banks, *55th issue (September 2018) of the International Journal of Central Banking* .

Ivashina, Victoria, David Scharfstein, and Jeremy Stein, 2015, Dollar funding and the lending behavior of global banks, *Quarterly Journal of Economics* 130, 1241–1282.

Kacperczyk, Marcin, and Philipp Schnabl, 2013, How safe are money market funds?, *The Quarterly Journal of Economics* 128, 1413–42.

Kalemli-Ozcan, Sebnem, Elias Papaioannou, and Fabrizio Perri, 2013, Global banks and crisis transmission, *Journal of International Economics* .

Kotidis, Antonis, and Neeltje Van Horen, 2018, Repo market functioning: The role of capital regulation .

Lagos, Ricardo, Guillaume Rocheteau, and Pierre-Olivier Weill, 2011, Crises and liquidity in over-the-counter markets, *Journal of Economic Theory* 146, 2169–2205.

Li, Yi, 2017, Reciprocal lending relationships in shadow banking.

Maggiori, Matteo, 2021, International macroeconomics with imperfect financial markets, in *Handbook of international economics* (The name of the publisher).

Malamud, Semyon, and Andreas Schrimpf, 2018, An intermediation-based model of exchange rates, BIS Working Papers 743, Bank for International Settlements.

Morelli, Juan, Pablo Ottonello, and Diego Perez, forthcoming, Global banks and systemic debt crises, *Econometrica* .

Munyan, Benjamin, 2015, Regulatory arbitrage in repo markets, Working Paper 15-22, Office of Financial Research.

Rime, Dagfinn, Andreas Schrimpf, and Olav Syrstad, 2017, Segmented money markets and covered interest parity arbitrage, BIS Working Paper 651, Bank for International Settlements.

Schmidt, Lawrence, Allan Timmermann, and Russ Wermers, 2016, Runs on money market mutual funds, *American Economic Review* 106, 2625–57.

Sushko, Vladyslav, Claudio Borio, Robert Neil McCauley, and Patrick McGuire, 2016, The failure of covered interest parity: FX hedging demand and costly balance sheets, Working Paper 590, Bank for International Settlements.

Wong, Alfred, David Leung, and Calvin Ng, 2017, Risk-adjusted covered interest parity: Theory and evidence, *Available at SSRN 2834798* .

Wong, Alfred, and Jiayue Zhang, 2018, Breakdown of covered interest parity: mystery or myth?, *Available at SSRN 3146652* .

Appendix A. Appendix to Section II – Institutional background and data

This appendix presents additional information on the sample. As discussed in the main text, our sample contains the positions of all money market funds (MMFs) domiciled in the United States and is based on their monthly filings to the Securities and Exchange Commission. The data provide detailed information on the MMFs themselves, as well as their portfolio holdings. It contains information on the instruments they invest in, such as repos, CP, CD, ABCP, Treasury debt or Agency debt, variable rate demand notes and other instruments. For all instruments, the dataset also provides information on the total amount of the transaction, the remaining maturity[37] and the yield, among other contract characteristics. In addition, for repos we observe whether the borrowing is backed by either Treasury, Government Agency or Other collateral.

Since our focus is on the interaction between MMFs and banks, we restrict the sample to repos, CP, CD and ABCP. MMFs act as cash lenders in repo transactions with banks, but also invest in CDs, CPs and ABCPs offered by banks. By regulation, MMFs are only allowed to invest in dollar-denominated instruments.

We link the contract-level information to the parent institution of the issuer, and then link this to the country of headquarters as in Chernenko and Sunderam (2014). This allows us to study the activity of a specific parent company across different market segments through their different controlled companies (say, CDs issued by different branches). After this aggregation, we restrict the sample of counterparties to include only Global Systemically Important Banks (GSIBs) and non-GSIB banks that are large and active in transacting with MMFs, which leaves us with 51 distinct banks. Furthermore, we exclude all observations with a reported interest rate of zero or missing, and we winsorize interest rates for the remaining sample at the 99.9% level in order to minimize the influence of outliers.[38]

Table VIII lists the banks included in our regression analysis, their country of headquarters, and aggregate information on their involvement in repo and unsecured contracts throughout the

[37] The data have information only on remaining maturity and do not have maturity at contract origination. Contracts with maturity that is longer than 30 days appear multiple times in the dataset. We identify such contracts and restrict our regressions to observations for which the contract appears for the first time.

[38] The results presented throughout are robust to using a non-winsorized sample, as well as winsorizing at different levels.

sample. Over the period from February 2011 to December 2017, we have 51 banks from 14 different countries. In the repo segment, our sample sample consists of a total of 205,165 contracts between 39 banks from 9 countries with 329 funds belonging to 70 fund families. In the unsecured segment (CP, CD and ABCP), in turn, we have 538,848 observations linking 49 banks from 14 countries with 175 funds belonging to 66 fund families. With the exception of banks from the US, banks are on average substantially more active in the unsecured segment of the market. Banks from some nationalities – notably China – do not engage in repo activity at all in our sample period.[39]

Table IX presents summary statistics aggregated at the bank nationality level, for both secured and unsecured markets. Banks from the US, France and Canada are the most active in repo markets (upper panel). They tend to transact with a large number of funds belonging to a wide variety of fund families. French banks in particular have large average contract size, with a relatively low average maturity. Canadian, Japanese and US banks are in turn the most active in unsecured markets. On average, there are less funds providing unsecured funding to non-US banks (175 funds in total, versus 329 for repos) – though the number of fund families in both markets is similar. Canadian banks stand out as the most diversified in terms of the number of funds they transact with.

[39] For repo contracts we exclude banks from Spain and Sweden as their repo volumes are very low. Our results are robust to their inclusion.

Table VIII
Banks in the sample

Country	Bank	# Repo Contracts	# Unsecured contracts
AU	Australia & New Zealand Banking Group Ltd	3	10181
AU	Commonwealth Bank of Australia	13	18038
AU	National Australia Bank Ltd	133	13153
AU	Westpac Banking Co	9	17954
BE	Dexia Group	.	1806
CA	Bank of Montreal	4435	21850
CA	Bank of Nova Scotia	5343	26990
CA	Canadian Imperial Bank of Commerce	305	9877
CA	Royal Bank of Canada	14319	31507
CA	Toronto-Dominion Bank	3752	22106
CH	Credit Suisse	13557	13746
CH	UBS	3275	5782
CN	Agricultural Bank of China Limited	.	415
CN	Bank of China Ltd	.	463
CN	China Construction Bank Co	.	930
CN	Industrial & Commercial Bank of China Ltd	.	660
DE	Commerzbank AG	305	232
DE	Deutsche Bank AG	11710	8727
ES	BBVA	.	118
ES	Banco Santander	.	1740
FI	Nordea	.	12071
FR	BNP Paribas	17323	17139
FR	BPCE	1211	9489
FR	Credit Agricole	5663	12840
FR	Societe Generale	8463	11436
GB	Barclays Bank PLC	11666	14332
GB	HSBC Holdings PLC	7063	13950
GB	Lloyds Banking Group	319	7542
GB	RBS	3960	2293
GB	Standard Chartered Bank	36	5070
JP	Mitsubishi UFJ Financial Group Inc	6218	36983
JP	Mizuho Financial Group	6402	17126
JP	Nomura	651	.
JP	Norinchukin Bank	723	6364
JP	Shizuoka Bank	.	386
JP	Sumitomo Mitsui Financial Group Inc	131	32476
JP	Sumitomo Mitsui Trust Bank	568	6743
NL	ABN Amro Bank	2381	2728
NL	ING Bank	7664	9691
NL	Rabobank	3	18820
SE	Skandinaviska Enskilda Banken AB	.	10210
SE	Svenska Handelsbanken	.	11820
SE	Swedbank AB	.	7038
US	Bank of America	16350	2084
US	Citigroup	10456	19532
US	Goldman Sachs	9841	38
US	JPMC	13388	28537
US	Morgan Stanley	2727	.
US	State Street	440	3981
US	The Bank of New York Mellon	950	367
US	Wells Fargo	13409	11487
Total		205165	538848

Table IX
Summary statistics

				Repos			
Nationality of bank	Nobs	No banks	No funds	No fund families	Avg contract size	Avg maturity	Avg rate
AU	158	4	17	6	255.3	2	86.3
BE		0	0	0			
CA	28,154	5	248	47	162.0	5	44.0
CH	16,832	2	205	40	156.2	16	38.4
CN		0	0	0			
DE	12,015	2	232	51	213.0	5	25.9
ES		0	0	0			
FI		0	0	0			
FR	32,660	4	234	41	267.9	4	38.0
GB	23,044	5	276	54	232.6	5	31.5
JP	14,693	6	176	32	166.0	6	62.8
NL	10,048	3	126	17	154.4	7	34.8
SE		0	0	0			
US	67,561	8	295	64	175.3	8	36.3
Total	205,165	39	329	70	193.7	6	38.0
				Unsecured funding - ABCP, CD, and CP			
AU	59,326	4	164	62	90.4	43	41.8
BE	1,806	1	43	16	76.2	63	55.9
CA	112,330	5	173	65	83.2	44	42.4
CH	19,528	2	138	45	111.4	50	42.1
CN	2,468	4	25	9	83.5	24	58.8
DE	8,959	2	111	39	105.5	52	33.4
ES	1,858	2	45	20	71.5	20	37.7
FI	12,071	1	128	45	90.1	72	36.8
FR	50,904	4	152	55	98.4	38	39.8
GB	43,187	5	153	55	82.2	48	39.7
JP	100,078	6	153	52	91.3	49	38.5
NL	31,239	3	151	57	95.6	57	40.0
SE	29,068	3	144	52	95.1	55	39.0
US	66,026	7	167	62	65.6	54	42.2
Total	538,848	49	175	66	87.6	48	40.5

Notes: Nobs = number of observations. No banks is the number of banks of a given nationality (location of headquarter). No funds and fund families denotes the total number of money market funds / fund families that banks of a given nationality transacted with. Avg contract size is the average transaction amount between a fund and a bank across banks of a given nationality in millions of USD. Avg maturity is the value-weighted average maturity, and avg rate denotes the corresponding interest rate.

Appendix B. Appendix to Section III – Pricing of dollar funding: the role of market structure

This appendix presents additional information regarding the role of relationships in the over-the-counter (OTC) market where banks and US money market funds (MMFs) interact. In addition, it also presents regression results to show the link between our measures of market/bargaining power and prices, as well as related robustness checks.

Relationships between US MMFs and banks

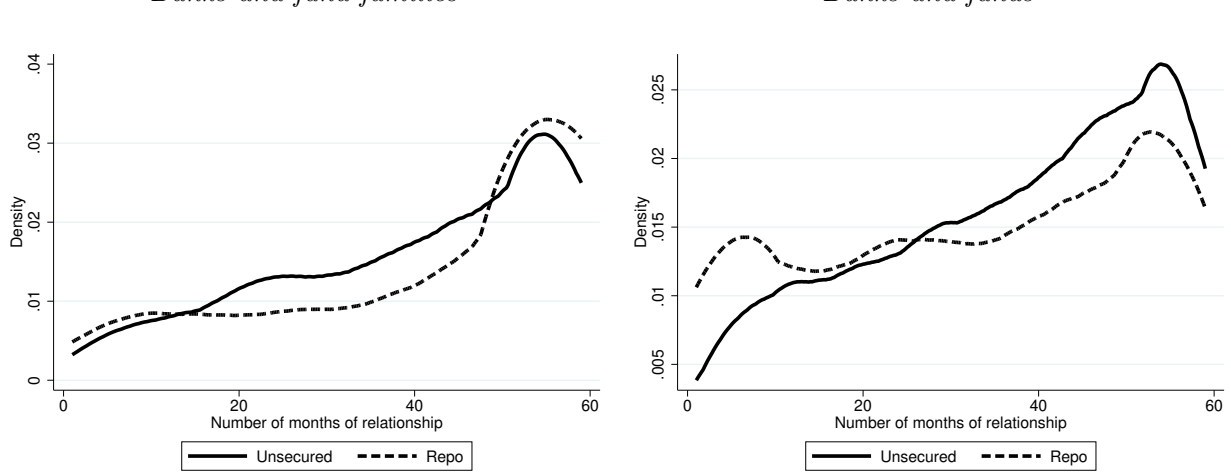
As in other OTC markets (Duffie, Gârleanu, and Pedersen (2005)), relationships tend to be sticky in our data. Figure 3 in the main text presents the density of the number of total months of relationships between banks and funds, as well as banks and fund families, as of the end of the sample in end-December 2017. The densities tend to be bimodal, with peaks on the lower and higher ends of the number of months a given relationships has lasted.

Bi-modality is driven by the inclusion of the US MMF reform in the sample. As Figure 10 shows, this disappears if we plot the same densities but with information as of the end of 2015, right before the implementation period of the MMF reform started. In this case, densities peak at the higher end – most relationships are long lasting, for funds and families and for both secured and unsecured segments. This suggests that the US MMF reform led to the breakdown of some relationships and the formation of new ones.

The establishment of long-term relationships helps to mitigate OTC search frictions. But this also comes at a cost: MMFs charge a higher price the longer the length of the relationship with their counterparties, even after controlling for relevant counterparty and contract characteristics (see the positive coefficient on the relationship length variable in Table II in the main text). However, this higher price can also have an insurance value, whereby higher prices in normal times compensate for sustained funding in periods of stress, in line with the relationship lending literature Elyasiani and Goldberg (2004).

We show that persistent relationships sheltered banks from losing funding from MMFs around the US MMF reform, when prime funds were forced to reduce the amount of unsecured funding. Table X presents the results of regressions that pool pre- and post-reform observations at the bank-

Figure 10
Density of the number of total months of relationships as of 31 December 2015



Sources: Crane data; authors' calculations.

fund family-time level, aiming to use relationship length to explain the likelihood of a relationship being cut (column (1)) post-reform, as well the percentage change in the average volume of monthly unsecured funding provided by a given fund family to a given bank post- versus pre-reform (columns (2) and (3)). Pre-reform relationship length is linked with a reduced likelihood of ties being cut post-reform, but it is not informative about the volume of funding post-reform.

Relationship between prices and market/bargaining power measures: additional results

In this section, we present robustness checks to the regressions relating pricing and market/bargaining power measures for the entire data sample. We also present evidence of how the bargaining power measures affect the explained variance of prices.

To address concerns about potential simultaneity bias, as well as concerns that our results might be driven by the inclusion of post-reform months, we present further robustness checks in Tables XI, XII and XIII respectively. Table XI presents a variation of Table II but computing our main measures based on the average of t and $t-1$ observations. Considering observations from the previous month can help address concerns over simultaneity bias, while keeping some role for month t observations allows us to not disregard many relevant observations that may occur earlier in the month and still be reflected in end-of-month positions. Table XII in turn takes this one step further by using only observations from $t-1$.

Table X
Relationships and the US MMF reform

	(1) $\mathbb{1}(CutReln_{bf^*t})$	(2) $\%\Delta_{bf^*t}$	(3) $\%\Delta_{bf^*t}$
$RelLength_{bf^*t-1}$	-0.005***	-0.120	-0.266
	(0.001)	(0.193)	(0.219)
$AvgMonthlyVol_{bf^*t-1}$	-0.038*	-20.830***	-39.600***
	(0.022)	(4.055)	(14.640)
$RelLength_{bf^*t-1} * AvgMonthlyVol_{bf^*t-1}$			0.347
			(0.234)
Observations	747	600	600
R-squared	0.313	0.465	0.467
Bank FE	✓	✓	✓
Fund Family FE	✓	✓	✓

Notes: Regressions are at bank-fund family-time level. The sample pools observations in 2015 as the "pre-period" and between October 2016 and March 2017 (both included) as the "post-period," resulting in two time periods for comparison. January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. The dependent variable in column (1) is a dummy variable that is 1 if the bank and the fund family do not have a counterparty relationship in the post-reform period in the unsecured segment while they had a relationship in the pre-implementation pre-period. The dependent variable in columns (2) and (3) are the percent change in the average volume of monthly unsecured funding between a bank and a fund family, averaged over the months of the pre-period versus the post-period. $RelLength_{bf^*t-1}$ is the number of months that the bank and the fund family had an ongoing relationship by December 2015. $AvgMonthlyVol_{bf^*t-1}$ is the average volume of monthly unsecured funding between a bank and a fund family, averaged over the months of the pre-period. Robust standard errors are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XIII presents a regression specification analogous to that in Table II but only focusing on the pre-reform sample to show that the results are not driven by the inclusion of the post-reform period in our original sample.

Overall, the results are similar across all our specifications.

Finally, we report the R^2 with various specifications in order to gauge how the bargaining power measures help with explaining the variation in pricing in each segment in Table XIV. Results indicate that *Date* fixed effects already account for a substantial portion of the variation in prices. Once contract controls and $Date * Instrument$ fixed effects are also included, the marginal contribution of our bargaining measures to the R^2 is rather low.[40] This is in part due to potential correlation of our measures with other control variables. When we only include the bargaining measures as independent variables, the R^2 is 5.01% in the unsecured segment and 4.24% in the repo segment. When we also include relationship controls, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$, and $TotVolume_{bf^*t}$, which measure the length of the relationship between the bank and the fund,

[40] An alternative way, which recovers the residuals from the specifications (2) for the unsecured segment and (6) for the repo segment and regresses those residuals on the market/bargaining power measures yields an R^2 of 0.77% and 1.11%, respectively.

Table XI

Market share and bargaining power measures and prices: averages between t and $t-1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Segment:	Repo	Repo	Unsec.	Unsec.	Repo	Repo	Unsec.	Unsec.
Measures:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
$MS_{ft,\bar{t-1}}$	0.06		0.33***					
	(0.15)		(0.11)					
$MS_{f^*t,\bar{t-1}}$		0.25***		0.04				
		(0.04)		(0.06)				
$MS_{bt,\bar{t-1}}$	-0.10***	-0.05	0.10	-0.05				
	(0.04)	(0.05)	(0.08)	(0.06)				
$FBP_{bft,\bar{t-1}}$					0.08***		0.04	
					(0.02)		(0.02)	
$BBP_{bft,\bar{t-1}}$					-0.01		-0.08*	
					(0.01)		(0.04)	
$FBP_{bf^*t,\bar{t-1}}$						0.06***		0.02
						(0.01)		(0.02)
$BBP_{bf^*t,\bar{t-1}}$						-0.05***		-0.05
						(0.01)		(0.04)
Control vars:								
$Log(value_{bfct})$	-0.15	0.09	-0.47**	-0.29	-0.15	0.03	-0.33	-0.25
	(0.14)	(0.11)	(0.24)	(0.21)	(0.14)	(0.12)	(0.23)	(0.21)
$5yCDS_{bt}$	0.02***	0.02***	0.04***	0.04***	0.03***	0.03***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Rem.mat_{bfct}$	0.36***	0.35***	0.06***	0.06***	0.36***	0.35***	0.06***	0.06***
	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)
$Rel.length_{bft}$	0.03***		0.01		0.03**		0.00	
	(0.01)		(0.03)		(0.01)		(0.03)	
$Rel.length_{bf^*t}$		0.02*		0.06***		0.02**		0.05**
		(0.01)		(0.02)		(0.01)		(0.02)
$TotVolume_{bft}$	0.13		-0.08		-0.05		0.42	
	(0.09)		(0.29)		(0.12)		(0.28)	
$TotVolume_{bf^*t}$		-0.07*		0.19**		0.05		0.19***
		(0.04)		(0.09)		(0.04)		(0.06)
Observations	176,835	179,230	259,451	262,646	164,634	176,573	245,417	253,938
R-squared	0.87	0.87	0.88	0.88	0.87	0.87	0.89	0.88
Date*FundType FE	✓	✓			✓	✓		
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest rate (in basis points) paid by a bank when borrowing from a fund. $MS_{ft,\bar{t-1}}$, $MS_{f^*t,\bar{t-1}}$ and $MS_{bt,\bar{t-1}}$ refer to the average of the current month and one month lagged market share of the fund, fund family and the bank, respectively, in the given segment (repo or unsecured) of the market. $FBP_{bfbart,t-1}$ (f^*) refers to the average of the current month and one month lagged share of a fund (fund family) for a bank at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). $BBP_{bft,\bar{t-1}}$ (f^*) refers to the average of the current month and one month lagged share of a bank for a fund (fund family) at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). Controls include $Log(value_{bfct})$ and $5yCDS_{bt}$, $Rem.maturity_{bfct}$, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$ and $TotVolume_{bf^*t}$ which measure the log size of the contract, 5-year CDS spread of the bank, the remaining maturity of the contract (taken as a proxy for maturity), the length of the relationship of the fund (or fund family) and the bank in the given segment and the total volume of contracts between a fund (or fund family) and a bank in a given segment at a given date. Instrument is one of ABCP, CP or CD in the unsecured segment and collateral type in the repo segment (Treasury, Agency or Other). Date*Fund Type FE are omitted in columns (3), (4), (7) and (8) since only prime funds provide unsecured funding. Standard errors clustered at the fund level are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XII

Market share and bargaining power measures and prices: measures calculated at $t-1$

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Segment:	Repo	Repo	Unsec.	Unsec.	Repo	Repo	Unsec.	Unsec.
Measures:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
MS_{ft-1}	0.08		0.31***					
	(0.15)		(0.11)					
MS_{f^*t-1}		0.25***		0.03				
		(0.04)		(0.06)				
MS_{bt-1}	-0.08**	-0.04	0.14*	-0.01				
	(0.04)	(0.04)	(0.07)	(0.06)				
FBP_{bft-1}					0.07***		0.04*	
					(0.02)		(0.02)	
BBP_{bft-1}					-0.01		-0.04	
					(0.01)		(0.04)	
FBP_{bf^*t-1}						0.06***		0.02
						(0.01)		(0.02)
BBP_{bf^*t-1}						-0.05***		-0.01
						(0.01)		(0.04)
Control vars:								
$Log(value_{bfct})$	-0.15	0.09	-0.46*	-0.28	-0.15	0.02	-0.32	-0.25
	(0.14)	(0.11)	(0.24)	(0.21)	(0.14)	(0.12)	(0.23)	(0.21)
$5yCDS_{bt}$	0.02***	0.02***	0.04***	0.04***	0.03***	0.03***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Rem.mat_{bfct}$	0.36***	0.35***	0.06***	0.06***	0.36***	0.35***	0.06***	0.06***
	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)
$Rel.length_{bft}$	0.03***		0.01		0.03**		0.00	
	(0.01)		(0.03)		(0.01)		(0.03)	
$Rel.length_{bf^*t}$		0.02		0.06***		0.02**		0.05**
		(0.01)		(0.02)		(0.01)		(0.02)
$TotVolume_{bft}$	0.11		-0.06		-0.04		0.37	
	(0.09)		(0.29)		(0.12)		(0.27)	
$TotVolume_{bf^*t}$		-0.08**		0.19**		0.05		0.17***
		(0.04)		(0.09)		(0.04)		(0.06)
Observations	176,835	179,230	259,451	262,646	164,634	176,573	245,417	253,938
R-squared	0.87	0.87	0.88	0.88	0.87	0.87	0.89	0.88
Date*FundType FE	✓	✓			✓	✓		
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest rate (in basis points) paid by a bank when borrowing from a fund. MS_{ft-1}, MS_{f^*t-1} and MS_{bt-1} refer to the one month lagged market share of the fund, fund family and the bank, respectively, in the given segment (repo or unsecured) of the market. FBP_{bft-1} (f^*) refers to the one month lagged share of a fund (fund family) for a bank at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). BBP_{bft-1} (f^*) refers to the one month lagged share of a bank for a fund (fund family) at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). Controls include $Log(value_{bfct})$ and $5yCDS_{bt}$, $Rem.maturity_{bfct}$, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$ and $TotVolume_{bf^*t}$ which measure the log size of the contract, 5-year CDS spread of the bank, the remaining maturity of the contract (taken as a proxy for maturity), the length of the relationship of the fund (or fund family) and the bank in the given segment and the total volume of contracts between a fund (or fund family) and a bank in a given segment at a given date. Instrument is one of ABCP, CP or CD in the unsecured segment and collateral type in the repo segment (Treasury, Agency or Other). Date*Fund Type FE are omitted in columns (3), (4), (7) and (8) since only prime funds provide unsecured funding. Standard errors clustered at the fund level are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XIII

Market share and bargaining power measures and prices: Pre-reform sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Segment:	Repo	Repo	Unsec.	Unsec.	Repo	Repo	Unsec.	Unsec.
Measures:	B-F	B-FF	B-F	B-FF	B-F	B-FF	B-F	B-FF
	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$	$Rate_{bfct}$
MS_{ft}	0.21		0.44**					
	(0.20)		(0.22)					
MS_{f^*t}		0.25***		0.17***				
		(0.04)		(0.05)				
MS_{bt}	-0.07	-0.06	0.04	-0.09				
	(0.04)	(0.05)	(0.08)	(0.06)				
FBP_{bft}					0.05***		0.04	
					(0.02)		(0.02)	
BBP_{bft}					-0.02		-0.11***	
					(0.01)		(0.03)	
FBP_{bf^*t}						0.05***		0.05***
						(0.01)		(0.01)
BBP_{bf^*t}						-0.07***		-0.09**
						(0.01)		(0.04)
Control vars:								
$Log(value_{bfct})$	-0.40**	-0.08	-0.48**	-0.42**	-0.37**	-0.14	-0.43**	-0.41**
	(0.16)	(0.13)	(0.24)	(0.18)	(0.16)	(0.14)	(0.22)	(0.18)
$5yCDS_{bt}$	0.02***	0.02***	0.04***	0.04***	0.02***	0.03***	0.04***	0.04***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$Rem.mat_{bfct}$	0.36***	0.35***	0.06***	0.06***	0.36***	0.35***	0.06***	0.06***
	(0.02)	(0.02)	(0.00)	(0.00)	(0.02)	(0.02)	(0.00)	(0.00)
$Rel.length_{bft}$	0.05***		-0.02		0.05***		-0.02	
	(0.02)		(0.04)		(0.02)		(0.04)	
$Rel.length_{bf^*t}$		0.03		0.05**		0.03*		0.05***
		(0.02)		(0.02)		(0.02)		(0.02)
$TotVolume_{bft}$	0.43**		-0.24		0.44*		0.55**	
	(0.18)		(0.35)		(0.27)		(0.23)	
$TotVolume_{bf^*t}$		0.09*		0.00		0.29***		0.16***
		(0.05)		(0.07)		(0.06)		(0.05)
Observations	142,262	142,262	228,572	228,572	142,262	142,262	228,572	228,572
R-squared	0.63	0.63	0.52	0.53	0.63	0.63	0.52	0.53
Date*Fund Type FE	✓	✓			✓	✓		
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest rate (in basis points) paid by a bank when borrowing from a fund. All regressions are for the period February 2011-September 2016. MS_{ft}, MS_{f^*t} and MS_{bt} refer to the market share of the fund, fund family and the bank, respectively, in the given segment (repo or unsecured) of the market. FBP_{bft} (f^*) refers to the share of a fund (fund family) for a bank at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). BBP_{bft} (f^*) refers to the share of a bank for a fund (fund family) at a given date measured for the repo segment in columns (5) and (6), and for the unsecured segment in columns (7) and (8). Controls include $Log(value_{bfct})$ and $5y\,CDS_{bt}$, $Rem.maturity_{bfct}$, $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$ and $TotVolume_{bf^*t}$ which measure the log size of the contract, 5-year CDS spread of the bank, the remaining maturity of the contract (taken as a proxy for maturity),the length of the relationship of the fund (or fund family) and the bank in the given segment and the total volume of contracts between a fund (or fund family) and a bank in a given segment at a given date. Instrument is one of ABCP, CP or CD in the unsecured segment and collateral type in the repo segment (Treasury, Agency or Other). Date*Fund Type FE are omitted in columns (3), (4), (7) and (8) since only prime funds provide unsecured funding. Standard errors clustered at the fund level are in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XIV
R^2 with various specifications

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Segment:	Unsec.	Unsec.	Unsec.	Unsec.	Unsec.	Repo	Repo	Repo	Repo	Repo
R^2	85.99%	87.91%	87.98%	5.01%	42.42%	69.46%	86.93%	87.09%	4.24%	27.80%
All BP measures			✓	✓	✓			✓	✓	✓
Relationship controls					✓					✓
Standard risk controls		✓	✓				✓	✓		
Date FE	✓					✓				
Date*Instrument FE		✓	✓				✓	✓		

Notes: The R^2 from regressing prices on various independent variables in each segment: All BP measures include all market and bargaining power measures: MS_{ft}, MS_{f^*t} and MS_{bt}, BBP_{bft}, BBP_{bf^*t}, FBP_{bft}, and FBP_{bf^*t}. Relationship controls include $Rel.length_{bft}$, $Rel.length_{bf^*t}$, $TotVolume_{bft}$, and $TotVolume_{bf^*t}$. Standard risk controls include $Log(value_{bfct})$, $Rem.maturity_{bfct}$, and $5y_C DS_{bt}$. Instrument is one of ABCP, CP or CD in the unsecured segment and collateral type in the repo segment (Treasury, Agency or Other).

the bank and the fund family, the total lending between the bank and the fund, and the bank and the family, respectively, the R^2 increases to 42.42% in the unsecured market and to 27.80% in the repo market. These results also paint a similar picture. Overall, macro and risk factors explain most of the pricing, but "non-risk" measures can also account for some variation in the whole data. As we explain in the main text as well, we are mostly interested in how our measures affect pricing, especially in stress episodes rather than the full sample.

Appendix C. Appendix to Section IV – The US MMF reform as a quasi-experiment

This appendix presents robustness checks for the results in Section IV, showing the causal effect of market and bargaining power on prices using the US money market fund (MMF) reform as a quasi experiment. The baseline regressions in Table III take a conservative approach by using 2015 as the pre-reform period – i.e., fully excluding the period between January 2016 (start of reform implementation) and the final implementation date in mid-October 2016.[41] In turn, the post-reform period starts in October 14 and concludes in end-March 2017. As noted in the main text, in the baseline regressions we keep the post-reform period relatively short as banks reacted to the loss of prime MMF funding by finding alternative sources of funding Aldasoro, Ehlers, Eren, and McCauley (2017b), which could potentially affect the dynamics of the interactions between banks and MMFs.

In the tables that follow we present regressions that follow the exact same structure as in Table III, but where we vary the post-reform period. In Table XV the post-reform period runs until end-June 2017, in Table XVI it goes until end-September 2017, and finally, in Table XVII the post-reform periods starts in January 2017 and ends in December 2017.

Our key results on market shares remain in place regardless of the specification. A difference that stands out between the regressions in the main text and those in Tables XV, XVI and XVII is that the interaction between the share of market share of banks (MS_{bt}) and the post-reform dummy becomes statistically significant (while remaining positive as in the main text), albeit the point estimate is quantitatively smaller than that corresponding to fund and fund family market shares.

In terms of the bargaining power measures, results also remain of the expected sign and statistically significant in Tables XV and XVI. As we exclude the last three months of 2016 and include instead the full 2017 as the post-period in Table XVII, the direction of the point estimates on the bargaining power measures FBP and BBP remains but their statistical significance fades. This suggests that with time banks potentially find other counterparties to counter the initial reduction

[41] As noted in the main text, much of the adjustment was backloaded and occurred in the couple of months immediately before final reform implementation.

in the outside options due to the reform.

These results are in line with expectations: as the post-reform period is expanded, banks are able to re-shuffle their relationships and find alternative funding sources, thereby increasing their outside options and moderating the (reform-induced) increased role of fund bargaining power.

Table XV

Market power and the MMF reform – Robustness: post-period until June 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-F $Rate_{bfct}$	(3) B-FF $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$	(5) B-F $Rate_{bfct}$	(6) B-F $Rate_{bfct}$	(7) B-FF $Rate_{bfct}$	(8) B-FF $Rate_{bfct}$
MS_{ft}	-2.22***	-1.87***						
	(0.59)	(0.67)						
$\mathbb{1}(Post_t) * MS_{ft}$	1.99***	1.82***						
	(0.48)	(0.53)						
MS_{f^*t}			-0.93**	-0.88**				
			(0.36)	(0.36)				
$\mathbb{1}(Post_t) * MS_{f^*t}$			0.86**	0.91***				
			(0.33)	(0.32)				
MS_{bt}	-1.40***	-1.29***	-1.35***	-1.30***				
	(0.26)	(0.31)	(0.28)	(0.33)				
$\mathbb{1}(Post_t) * MS_{bt}$	0.32	0.31	0.28	0.29				
	(0.22)	(0.25)	(0.20)	(0.23)				
FBP_{bft}					0.01	-0.03		
					(0.03)	(0.05)		
$\mathbb{1}(Post_t) * FBP_{bft}$					0.09	0.05		
					(0.07)	(0.07)		
BBP_{bft}					-0.04	-0.06		
					(0.05)	(0.05)		
$\mathbb{1}(Post_t) * BBP_{bft}$					-0.06	-0.21**		
					(0.10)	(0.10)		
FBP_{bf^*t}							0.05**	-0.01
							(0.02)	(0.02)
$\mathbb{1}(Post_t) * FBP_{bf^*t}$							0.09*	0.07*
							(0.05)	(0.04)
BBP_{bf^*t}							-0.02	-0.03
							(0.06)	(0.06)
$\mathbb{1}(Post_t) * BBP_{bf^*t}$							-0.10	-0.21**
							(0.11)	(0.10)
Observations	67,678	67,418	67,678	67,418	67,627	67,364	67,627	67,364
R-squared	0.91	0.93	0.91	0.93	0.93	0.95	0.93	0.95
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE	✓		✓					
Fund FE	✓		✓					
Bank*Fund FE		✓		✓		✓		✓
Bank*Date FE					✓	✓	✓	✓
Fund*Date FE					✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank when borrowing from a fund. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and June 2017 (both included) as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5yCDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XVI

Market power and the MMF reform – Robustness checks: post-period until September 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-F $Rate_{bfct}$	(3) B-FF $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$	(5) B-F $Rate_{bfct}$	(6) B-F $Rate_{bfct}$	(7) B-FF $Rate_{bfct}$	(8) B-FF $Rate_{bfct}$
MS_{ft}	-1.91***	-1.51**						
	(0.60)	(0.73)						
$\mathbb{1}(Post_t) * MS_{ft}$	1.74***	1.52***						
	(0.47)	(0.57)						
MS_{f^*t}			-0.87**	-0.80**				
			(0.36)	(0.38)				
$\mathbb{1}(Post_t) * MS_{f^*t}$			0.80**	0.84**				
			(0.32)	(0.33)				
MS_{bt}	-1.13***	-0.98***	-1.11***	-1.07***				
	(0.26)	(0.31)	(0.28)	(0.32)				
$\mathbb{1}(Post_t) * MS_{bt}$	0.34	0.19	0.32	0.27				
	(0.21)	(0.23)	(0.19)	(0.21)				
FBP_{bft}					0.00	-0.01		
					(0.03)	(0.05)		
$\mathbb{1}(Post_t) * FBP_{bft}$					0.07	0.04		
					(0.07)	(0.07)		
BBP_{bft}					-0.04	-0.06		
					(0.05)	(0.05)		
$\mathbb{1}(Post_t) * BBP_{bft}$					-0.08	-0.23**		
					(0.09)	(0.09)		
FBP_{bf^*t}							0.04*	-0.01
							(0.02)	(0.02)
$\mathbb{1}(Post_t) * FBP_{bf^*t}$							0.06	0.05
							(0.04)	(0.04)
BBP_{bf^*t}							-0.03	-0.04
							(0.06)	(0.06)
$\mathbb{1}(Post_t) * BBP_{bf^*t}$							-0.08	-0.18*
							(0.11)	(0.10)
Observations	77,360	77,115	77,360	77,115	77,307	77,061	77,307	77,061
R-squared	0.93	0.95	0.93	0.95	0.95	0.96	0.95	0.96
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE	✓		✓					
Fund FE	✓		✓					
Bank*Fund FE		✓		✓		✓		✓
Bank*Date FE					✓	✓	✓	✓
Fund*Date FE					✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank b when borrowing from a fund f. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and September 2017 (both included) as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5yCDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XVII

Market power and the MMF reform – Robustness checks: post-period January-December 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-F $Rate_{bfct}$	(3) B-FF $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$	(5) B-F $Rate_{bfct}$	(6) B-F $Rate_{bfct}$	(7) B-FF $Rate_{bfct}$	(8) B-FF $Rate_{bfct}$
MS_{ft}	-1.65***	-1.34**						
	(0.55)	(0.64)						
$\mathbb{1}(Post_t) * MS_{ft}$	1.51***	1.32**						
	(0.43)	(0.51)						
MS_{f^*t}			-0.71**	-0.66*				
			(0.35)	(0.37)				
$\mathbb{1}(Post_t) * MS_{f^*t}$			0.62**	0.66**				
			(0.31)	(0.32)				
MS_{bt}	-0.85***	-0.78***	-0.82***	-0.85***				
	(0.25)	(0.30)	(0.26)	(0.30)				
$\mathbb{1}(Post_t) * MS_{bt}$	0.33	0.05	0.32	0.22				
	(0.21)	(0.23)	(0.20)	(0.19)				
FBP_{bft}					0.01	-0.02		
					(0.03)	(0.04)		
$\mathbb{1}(Post_t) * FBP_{bft}$					0.02	0.01		
					(0.06)	(0.05)		
BBP_{bft}					-0.04	-0.05		
					(0.05)	(0.05)		
$\mathbb{1}(Post_t) * BBP_{bft}$					-0.07	-0.19**		
					(0.08)	(0.09)		
FBP_{bf^*t}							0.05**	-0.00
							(0.02)	(0.02)
$\mathbb{1}(Post_t) * FBP_{bf^*t}$							0.01	-0.01
							(0.04)	(0.04)
BBP_{bf^*t}							-0.02	-0.03
							(0.06)	(0.06)
$\mathbb{1}(Post_t) * BBP_{bf^*t}$							-0.07	-0.15
							(0.10)	(0.10)
Observations	82,290	82,034	82,290	82,034	82,243	81,984	82,243	81,984
R-squared	0.95	0.96	0.95	0.96	0.96	0.97	0.96	0.97
Controls	✓	✓	✓	✓	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE	✓		✓					
Fund FE	✓		✓					
Bank*Fund FE		✓		✓		✓		✓
Bank*Date FE					✓	✓	✓	✓
Fund*Date FE					✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank b when borrowing from a fund f. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and 2017 as the "post-period." In this robustness check, January 2016 - December 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.\,maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

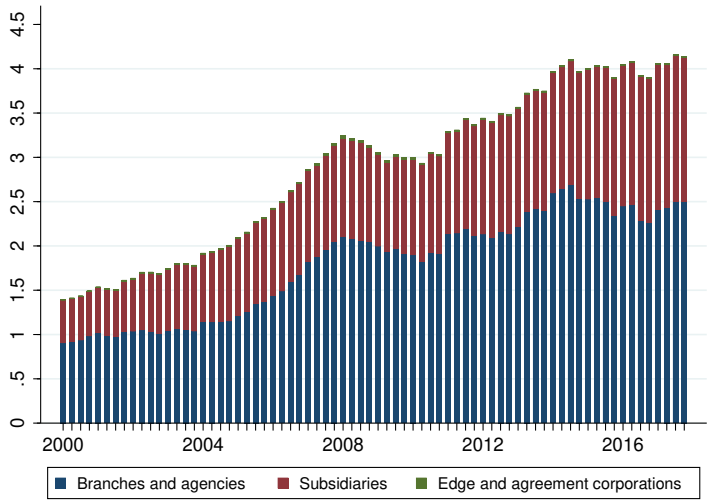
Appendix D. Appendix to Section V – Heterogeneous dollar funding demand, market frictions and regulation

Business models of US affiliates of non-US banks

In this appendix, we provide additional background to our discussion in subsection V.A by documenting the time series evolution of individual items in banks' balance sheets. We also provide a brief discussion of the role of the different US affiliates of non-US banks.

Non-US global banks conduct a significant part of their dollar business in the United States through their affiliates. According to their regulatory filings,[42] these affiliates had in aggregate around $4.1 trillion in assets as of end-2017, 28% higher than their pre-crisis peak. Slightly over 60% and 39% is accounted for by branches and agencies, and subsidiaries respectively.

Figure 11
The size of the US affiliates of non-US banks
By affiliate type (in $ trillions)



Source: US Call reports (FFIEC 002, FFIEC 031/041, FR 2886b); authors' calculations

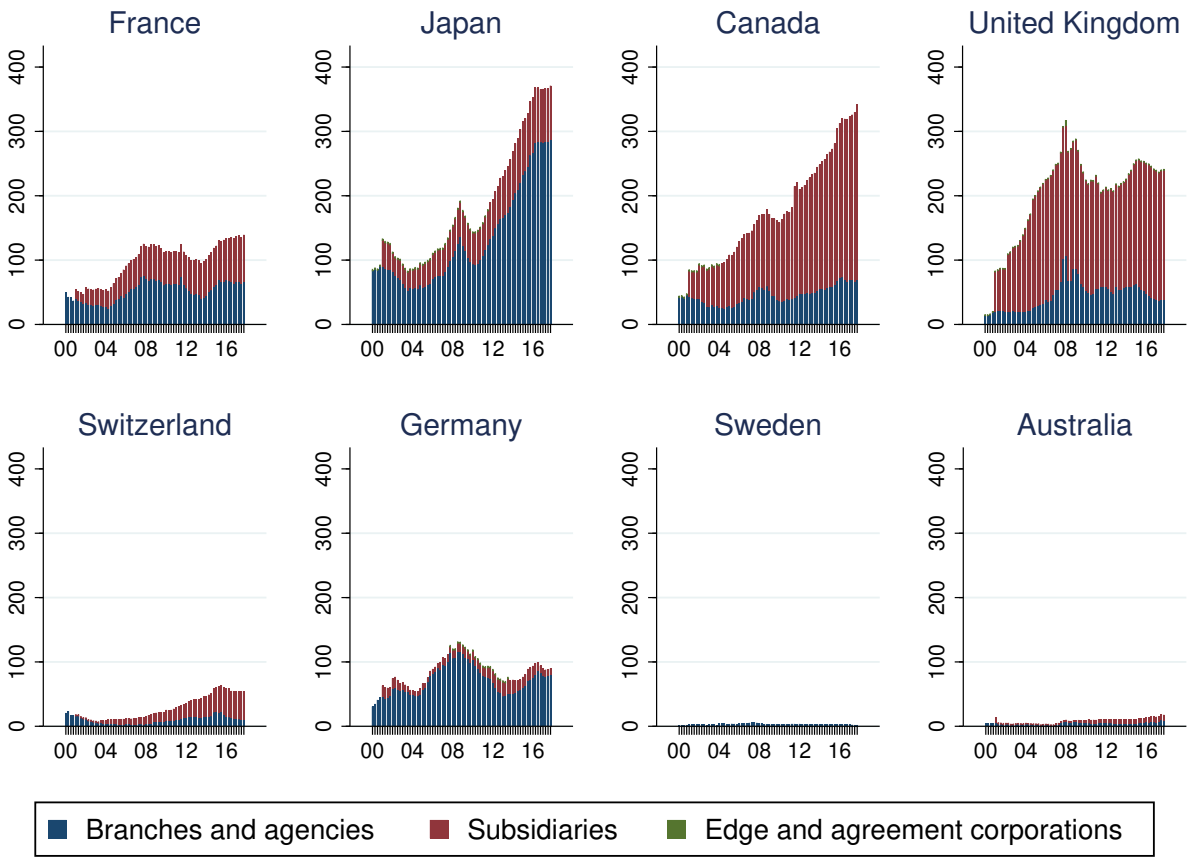
Branches, regardless of whether they are foreign or US-owned, are different from US-chartered banks in that they are not separately capitalized nor report earnings on a stand-alone basis. What distinguishes US branches of foreign banks from the domestic branches of US banks is that the former are prohibited from taking retail deposits (deposits ¡$100.000) from US residents. As a

[42] The affiliates comprise branches and agencies, subsidiaries, and edge and agreement corporations. They respectively file the forms FFIEC 002, FFIEC 031/041 and FR 2886b.

consequence, a significant share of the funding of these foreign-owned branches and agencies therefore comes from institutional investors, most notably money market funds (MMFs). Subsidiaries, however, also obtain funding from MMFs.

There has been a drastic change in the sources and uses of dollars of non-US global banks post-GFC (see Figure 6 in the main text). The first notable difference regards the loan books of banks from different nationalities (Figure 12). Japanese banks in particular increased their loans substantially (over $200 billion) post-GFC, especially through their branches – their preferred mode of establishing affiliates in the United States. Canadian banks have large US subsidiaries, which also increased their loan books significantly. In contrast, European banks loan books never truly recovered their pre-GFC trend and stayed rather flat in the decade to 2017.

Figure 12
Loans of US affiliates of non-US banks
By affiliate type and bank nationality (in $ billions)



Source: US Call reports (FFIEC 002, FFIEC 031/041, FR 2886b); authors' calculations

A second important difference regards the use that banks make of repo markets (Figure 13). On one hand, French and Canadian banks stand out as large repo intermediaries, i.e. they have large reverse repos on their asset side, matched with repos on their liability side. While this has traditionally being their business model in repo markets, they significantly expanded the size of their matched books after 2011. On the other hand, Japanese banks stand out as unique players that use repo markets only for funding. Like in the case of French and Canadian banks, this funding profile intensified in recent years.

Figure 13
Repos and reverse repos of the US affiliates of non-US banks
By bank nationality (in $ billions)

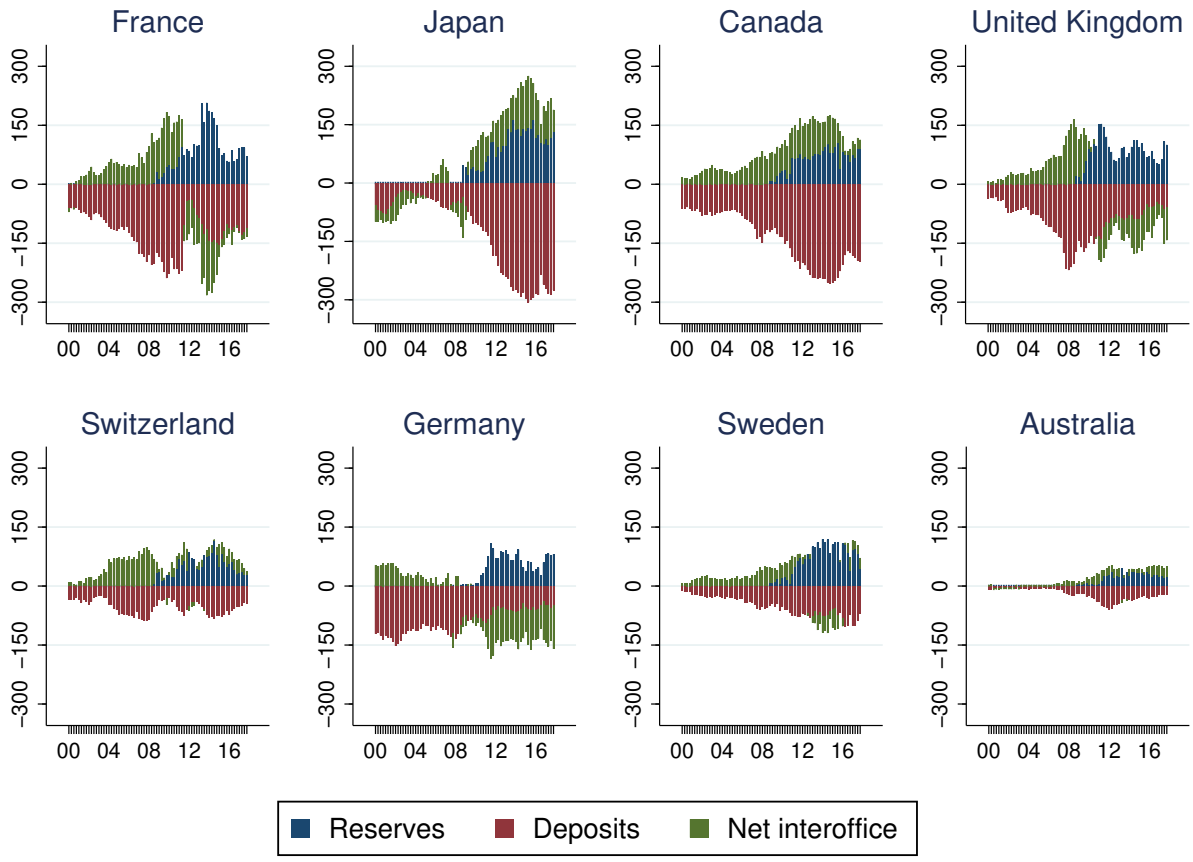
Source: US Call reports (FFIEC 002, FFIEC 031/041, FR 2886b); authors' calculations
Note: Positive numbers refer to assets and negative numbers refer to liabilities.

A third important difference is the shift towards short-term arbitrage of interest on excess reserves by the branches and agencies of European banks after 2011 (Figure 14).[43] French, UK and

[43]We emphasize branches and agencies here as these cannot take retail deposits from US citizens or residents,

German banks went from being net providers of dollar liquidity to their non-US offices to being net receivers of dollars funds from these offices. Swiss and Swedish banks, in turn, borrowed short-term unsecured funding to invest in interest-paying reserves (see also Banegas and Tase (2016) for a discussion of this arbitrage). Japanese and Canadian banks also increased their reserves, but kept on being net providers of dollar funds to their related offices outside of the United States.

Figure 14
Reserves, deposits, and net interoffice positions of the US branches and agencies of non-US banks
By bank nationality (in $ billions)



Source: US Call reports (FFIEC 002); authors' calculations.
Note: For net interoffice positions positions, a positive number means that the US affiliate has claims on other offices and vice versa. Net interoffice positions are aggregated across banks.

Shrinking loan books and the use of dollar liquidity for arbitrage have made the dollar operations of European banks more short-term oriented and more easily scalable compared to those of Japanese

hence *Deposits* essentially represents (mostly short-term) wholesale funding.

banks. Moreover, Japanese banks rely more on dollars sourced in the United States than other banks, arguably making their demand for dollar funding less elastic.

Japanese banks and the price of unsecured funding: robustness

This appendix presents robustness checks for the results in Section V.B, showing the causal effect of market and bargaining power on prices using the US money market fund (MMF) reform as a quasi experiment and focusing on the case of Japanese banks. For a discussion of the choice of baseline period for the MMF reform we refer the reader to Appendix C which present the robustness checks for our main results on the role of market/bargaining power.

In the tables that follow we present regressions that follow a structure similar to Table V, but where we vary the post-reform period. In Table XVIII the post-reform period runs until end-June 2017, in Table XIX it goes until end-September 2017, and finally, in Table XX the post-reform periods starts in January 2017 and ends in December 2017.

All results for the triple interaction presented in the main text (for market shares as well as the FBP indicator at the fund family level) are robust to all sample variations presented in the three tables.[44] As we expand the post-reform sample, the point estimate for the BV measure becomes somewhat smaller, though it retains its statistical significance. This is in line with expectations: as the post-reform period is expanded, banks are able to re-shuffle their relationships and find alternative funding sources, thereby increasing their outside options and moderating the (reform-induced) increased role of fund bargaining power.

[44] In these robustness exercises, also the triple interaction with the FBP measure at the fund level becomes statistically significant.

Table XVIII

The US MMF reform and the pricing of unsecured funding for Japanese banks: post-period until June 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-FF $Rate_{bfct}$	(3) B-F $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$
$\mathbb{1}(JP_b) * MS_{ft}$	-0.10			
	(0.15)			
$\mathbb{1}(JP_b) * MS_{ft} * \mathbb{1}(Post_t)$	0.34			
	(0.38)			
$\mathbb{1}(JP_b) * MS_{f^*t}$		0.04		
		(0.09)		
$\mathbb{1}(JP_b) * MS_{f^*t} * \mathbb{1}(Post_t)$		0.40**		
		(0.18)		
BBP_{bft}			-0.06	
			(0.04)	
FBP_{bft}			0.01	
			(0.03)	
$\mathbb{1}(JP_b) * FBP_{bft}$			-0.13	
			(0.08)	
$FBP_{bft} * \mathbb{1}(Post_t)$			0.07	
			(0.08)	
$\mathbb{1}(JP_b) * FBP_{bft} * \mathbb{1}(Post_t)$			0.23	
			(0.16)	
BBP_{bf^*t}				-0.07
				(0.05)
FBP_{bf^*t}				0.07**
				(0.03)
$\mathbb{1}(JP_i) * FBP_{bf^*t}$				0.02
				(0.05)
$FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.04
				(0.05)
$\mathbb{1}(JP_b) * FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.29***
				(0.11)
Observations	67,627	67,627	67,627	67,627
R-squared	0.93	0.93	0.93	0.93
Controls	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓
Fund*Date FE	✓	✓	✓	✓
Bank*Date FE	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank when borrowing from a fund. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and June 2017 (both included) as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(JP_b)$ is a dummy variable that is one if the bank is headquartered in Japan. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XIX

The US MMF reform and the pricing of unsecured funding for Japanese banks

Robustness: post-period until September 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-FF $Rate_{bfct}$	(3) B-F $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$
$\mathbb{1}(JP_b) * MS_{ft}$	-0.11			
	(0.15)			
$\mathbb{1}(JP_b) * MS_{ft} * \mathbb{1}(Post_t)$	0.21			
	(0.32)			
$\mathbb{1}(JP_b) * MS_{f^*t}$		0.04		
		(0.09)		
$\mathbb{1}(JP_b) * MS_{f^*t} * \mathbb{1}(Post_t)$		0.32**		
		(0.15)		
BBP_{bft}			-0.08*	
			(0.04)	
FBP_{bft}			0.01	
			(0.03)	
$\mathbb{1}(JP_b) * FBP_{bft}$			-0.14*	
			(0.08)	
$FBP_{bft} * \mathbb{1}(Post_t)$			0.05	
			(0.07)	
$\mathbb{1}(JP_b) * FBP_{bft} * \mathbb{1}(Post_t)$			0.15	
			(0.14)	
BBP_{bf^*t}				-0.07
				(0.05)
FBP_{bf^*t}				0.06**
				(0.03)
$\mathbb{1}(JP_i) * FBP_{bf^*t}$				0.02
				(0.05)
$FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.03
				(0.05)
$\mathbb{1}(JP_b) * FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.24**
				(0.10)
Observations	77,307	77,307	77,307	77,307
R-squared	0.95	0.95	0.95	0.95
Controls	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓
Fund*Date FE	✓	✓	✓	✓
Bank*Date FE	✓	✓	✓	✓

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank b when borrowing from a fund f. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and between October 2016 and September 2017 (both included) as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(JP_b)$ is a dummy variable that is one if the bank is headquartered in Japan. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Table XX

The US MMF reform and the pricing of unsecured funding for Japanese banks

Robustness: post-period January-December 2017

Measure:	(1) B-F $Rate_{bfct}$	(2) B-FF $Rate_{bfct}$	(3) B-F $Rate_{bfct}$	(4) B-FF $Rate_{bfct}$
$\mathbb{1}(JP_b) * MS_{ft}$	-0.08			
	(0.15)			
$\mathbb{1}(JP_b) * MS_{ft} * \mathbb{1}(Post_t)$	0.15			
	(0.29)			
$\mathbb{1}(JP_b) * MS_{f^*t}$		0.08		
		(0.09)		
$\mathbb{1}(JP_b) * MS_{f^*t} * \mathbb{1}(Post_t)$		0.29*		
		(0.15)		
BBP_{bft}			-0.07	
			(0.04)	
FBP_{bft}			0.02	
			(0.03)	
$\mathbb{1}(JP_b) * FBP_{bft}$			-0.12	
			(0.08)	
$FBP_{bft} * \mathbb{1}(Post_t)$			0.01	
			(0.06)	
$\mathbb{1}(JP_b) * FBP_{bft} * \mathbb{1}(Post_t)$			0.12	
			(0.12)	
BBP_{bf^*t}				-0.06
				(0.05)
FBP_{bf^*t}				0.07***
				(0.03)
$\mathbb{1}(JP_i) * FBP_{bf^*t}$				0.04
				(0.05)
$FBP_{bf^*t} * \mathbb{1}(Post_t)$				-0.03
				(0.05)
$\mathbb{1}(JP_b) * FBP_{bf^*t} * \mathbb{1}(Post_t)$				0.17**
				(0.09)
Observations	82,243	82,243	82,243	82,243
R-squared	0.96	0.96	0.96	0.96
Controls	✓	✓	✓	✓
Date*Instrument FE	✓	✓	✓	✓
Fund*Date FE	✓	✓	✓	✓
Bank*Date FE	✓	✓	✓	✓

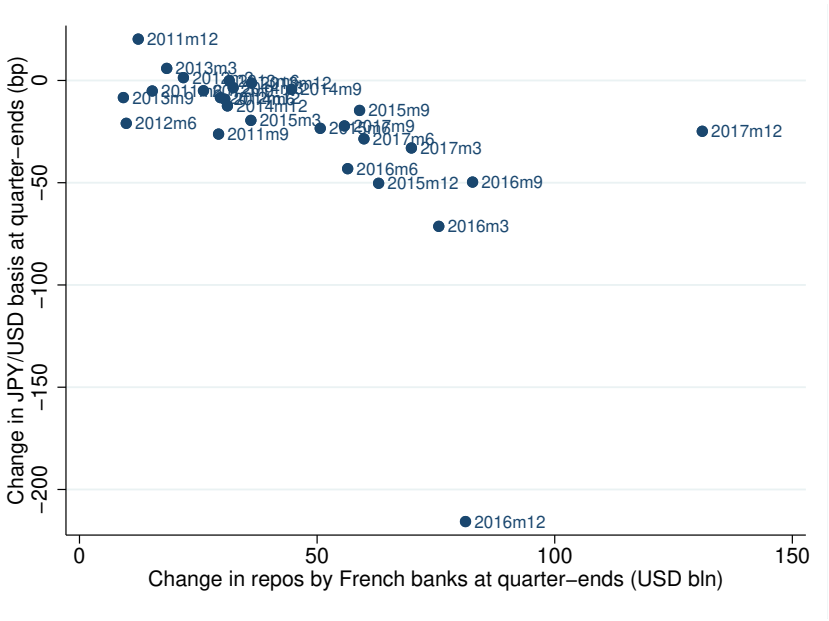
Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank b when borrowing from a fund f. All regressions refer to unsecured (CP, CD, ABCP) contracts. The sample contains observations in 2015 as the "pre-period" and 2017 as the "post-period." January 2016 - September 2016 correspond to the implementation period and observations between those dates are omitted. MS_{f^*t} is the market share of the fund family in the unsecured segment. MS_{ft} is the market share of the fund in the unsecured segment. MS_{bt} is the market share of the bank in the unsecured segment. FBP_{bf^*t} is the share of a given fund family in the borrowing of a given bank. FBP_{bft} is the share of a given fund in the borrowing of a given bank. BBP_{bf^*t} is the share of a bank in the lending of a fund family. BBP_{bft} is the share of a bank in the lending of a fund. $\mathbb{1}(JP_b)$ is a dummy variable that is one if the bank is headquartered in Japan. $\mathbb{1}(Post_t)$ is a dummy variable that is one if date is later than October 14, 2016 - the implementation date of the reform. Controls include $Log(value_{bfct})$, $5y\,CDS_{bt}$, $Rem.maturity_{bfct}$, $RelLength_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) and $TotVolume_{bft}$ (measured either at bank-fund or bank-fund family level depending on the specification) in all columns. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

Spillovers of quarter-end repo disruptions into FX swaps – additional tables and figures

This appendix presents additional results regarding spillovers from repo disruptions into FX swaps. Figure 15 presents the quarter-end changes in the French banks' repos with MMFs versus the quarter-end changes in the JPY/USD cross-currency basis, where changes are with respect to the previous month. Given the prevalence of reporting requirements (including, e.g. GSIB scores) at year-ends, larger pricing disruptions occur on those dates. Indeed, the year-ends of 2016 and 2017 were clear outliers. We exclude these two observations from the spillover regressions.

Figure 15

Changes in repos by French banks versus changes in JPY/USD basis at quarter ends



Sources: Crane data; Bloomberg; authors' calculations.

The spillover effect from French banks' repo window-dressing documented in Table VII is not present for the other group of large repo intermediaries, namely Canadian banks. Table XXI presents the results of a regression similar to the one in Equation 12, but considering the changes in repo activity of Canadian banks instead of French banks. The coefficient is not statistically significant for any maturity of the JPY/USD basis. Similarly, in Table XXII we do a similar exercise but considering the repos of other non-French European with quarter-end reporting, namely German, Dutch and Swiss banks taken together. Again, we do no see any significant effect across maturities.

Table XXI

The quarter-end effect: Canadian banks and the JPY/USD basis

	(1) 1W	(2) 1W	(3) 3M	(4) 3M	(5) 1Y	(6) 1Y
ΔCA repo	-0.52	-0.63	-1.06**	-0.66	-0.21	-0.20
	(1.20)	(0.94)	(0.51)	(0.54)	(0.36)	(0.30)
$\Delta EUR/USD\ basis$ (1W)		1.05***				
		(0.32)				
$\Delta EUR/USD\ basis$ (3M)				0.51***		
				(0.18)		
$\Delta EUR/USD\ basis$ (1Y)						0.34**
						(0.17)
Observations	23	23	23	23	23	23
R-squared	0.01	0.40	0.16	0.42	0.02	0.26

Notes: Bootstrapped standard errors (from 1,000 replications) are in parentheses. ***, **, * denote significance at the 10, 5 and 1% level respectively. 1W, 3M and 1Y refer to the contemporaneous changes in the 1-week, 3-month and 1-year basis, respectively. The dependent variable is the change in the JPY/USD basis at different maturities. ΔCA repo stands for the (absolute value of) changes in repos with MMFs done by Canadian banks. The control $\Delta EUR/USD\ basis$ is constructed in the same manner as the dependent variable and has the same tenor as the dependent variable for each column. Changes are computed as $month_{quarter-end} - month_{quarter-end-1}$ (the absolute value is taken for changes in Canadian banks' repos with MMFs (in $billions)). The sample runs from December 2011 (Q4 2011) to September 2017 (Q3 2017). The outlier observations corresponding to December 2016 and December 2017 are excluded.

Table XXII

The quarter-end effect: European banks and the JPY/USD basis

	(1) 1W	(2) 1W	(3) 3M	(4) 3M	(5) 1Y	(6) 1Y
ΔEU repo	0.10	-0.08	-0.09	-0.09	0.00	-0.07
	(0.36)	(0.34)	(0.22)	(0.20)	(0.10)	(0.12)
$\Delta EUR/USD\ basis$ (1W)		1.06***				
		(0.31)				
$\Delta EUR/USD\ basis$ (3M)				0.57***		
				(0.16)		
$\Delta EUR/USD\ basis$ (1Y)						0.37**
						(0.17)
Observations	23	23	23	23	23	23
R-squared	0.00	0.39	0.01	0.37	0.00	0.26

Notes: Bootstrapped standard errors (from 1,000 replications) are in parentheses. ***, **, * denote significance at the 10, 5 and 1% level respectively. 1W, 3M and 1Y refer to the contemporaneous changes in the 1-week, 3-month and 1-year basis, respectively. The dependent variable is the change in the JPY/USD basis at different maturities. ΔEU repo stands for the (absolute value of) changes in repos with MMFs done by European banks(from Germany, the Netherlands and Switzerland). The control $\Delta EUR/USD\ basis$ is constructed in the same manner as the dependent variable and has the same tenor as the dependent variable for each column. Changes are computed as $month_{quarter-end} - month_{quarter-end-1}$ (the absolute value is taken for changes in European banks' repos with MMFs (in $billions)). The sample runs from December 2011 (Q4 2011) to September 2017 (Q3 2017). The outlier observations corresponding to December 2016 and December 2017 are excluded.

Finally, we present the estimates of implied profits from intermediation through maturity and collateral transformation. Table XXIII presents the results of estimating the following equation for

the repo market:

$$Rate_{bfct} = \delta_1 Log(value_{bfct}) + \delta_2 5y\,CDS_{bt} + \delta_3 \mathbb{1}(JP_b) + \delta_4 Rem.\,maturity_{bfct} + \delta_5 \mathbb{1}(JP_b) * Rem.\,maturity_{bfct} + \eta_{t,type(f)} + \eta_{t,coll(c)} + \epsilon_{bfct} \tag{D1}$$

Maturity transformation, whereby other banks borrow overnight and lend at 30 days to Japanese banks (charging the MMF price), all else constant, earns *16 basis points*. We calculate this by adding up the coefficients of $\mathbb{1}(JP_b)$, $30 * Rem.\,maturity_{bfct}$ and the interaction term $30 * (\mathbb{1}(JP_b) * Rem.\,maturity_{bfct})$, that is $\delta_3 + 30 * \delta_4 + 30 * \delta_5$. These spreads are both statistically and economically significant. Implied profits from collateral transformation can also be large.[45] We estimate that, all else equal, if a non-Japanese bank pledges US Treasuries to MMFs and receives "Other collateral" from Japanese banks, charging the MMF price, the spread would be 32 basis points.[46]

Importantly, these intermediation spreads are largely free of any regulatory costs potentially arising from such intermediation. Since the leverage ratio is based on quarter-end data for European banks, they can engage in such intermediation for most of the quarter, unwind their positions at quarter-ends, only to return to this intermediation immediately after quarter-ends. For example, at the extreme, a European bank engaging in a reverse repo, lending to another bank on April 1 (the day after a quarter-end) with maturity date June 29 (the day before the next quarter-end), would not incur *any* leverage ratio-related regulatory costs.

[45] There are many reasons why banks would like to use non-Treasury collateral in repos, one of which would be to improve the Liquidity Coverage Ratio under Basel III regulations.

[46] The calculation of implied profits follows a similar logic to that for implied profits from maturity transformation.

Table XXIII

Intermediation spreads from maturity or collateral transformation to Japanese banks

	(1) $Rate_{bfct}$	(2) $Rate_{bfct}$
$\mathbb{1}(JP_b)$	1.32	2.05***
	(0.92)	(0.40)
$Rem.Maturity_{bfct}$	0.35***	0.36***
	(0.02)	(0.02)
$Rem.Maturity_{bfct}$*$\mathbb{1}(JP_b)$	0.14*	
	(0.07)	
$\mathbb{1}(GovernmentAgencyRepo_{bfct})$		1.47***
		(0.33)
$\mathbb{1}(OtherRepo_{bfct})$		25.90***
		(1.03)
$\mathbb{1}(JP_b)$*$\mathbb{1}(GovernmentAgencyRepo_{bfct})$		-0.99
		(0.75)
$\mathbb{1}(JP_b)$*$\mathbb{1}(OtherRepo_{bfct})$		3.96**
		(1.99)
Observations	181,425	181,425
R-squared	0.87	0.87
Controls	✓	✓
Date*Fund Type FE	✓	✓
Date*Collateral FE	✓	

Notes: Regressions are at the contract level and the dependent variable is the interest (in basis points) paid by a bank when borrowing from a fund. All regressions refer to repo contracts. Full sample includes banks from the United States, Canada, Japan, France, Switzerland, the United Kingdom, Germany, the Netherlands and Australia. $\mathbb{1}(JP_b)$ is a dummy variable that is 1 if the bank is from Japan. Treasury collateral is taken as baseline in (2) and is therefore omitted. $\mathbb{1}(GovernmentAgencyRepo_{bfct})$ indicates whether the collateral is a government agency security. $\mathbb{1}(JP_b)$*$\mathbb{1}(OtherRepo_{bfct})$ indicates whether collateral is other than Treasury or government agency securities. Controls include $Log(value_{bfct})$, $5yCDS_{bt}$ and $Date*FundTypeFE$ in both columns and also $Date*CollateralFE$ in the first column. Standard errors clustered at the fund level in parentheses. ***, **, * denote significance at the 1, 5 and 10% level respectively.

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