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Spillovers of Funding Dry-ups*

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ABSTRACT

We uncover a new channel for spillovers of funding dry-ups. The 2016 US money market fund (MMF) reform exogenously reduced unsecured MMF funding for some banks. We use novel data to trace those banks to a platform for corporate deposit funding. We show that intensified competition for corporate deposits spilled the funding squeeze over to other banks with no MMF exposure. These banks paid more for deposits, and their pool of funding providers deteriorated. Moreover, their lending volumes and margins declined, and their stocks underperformed. Our results suggest that banks' competitiveness in funding markets affect their competitiveness in lending markets.

JEL classification: G21, G28
Keywords: funding dry-ups, competition, spillovers, money market funds, corporate deposits, dollar funding

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I. Introduction

Dry-ups in funding markets often lead to financial crises, with adverse macroeconomic consequences. Hence, understanding their dynamics is important. However, isolating the effect of a funding dry-up from broader crisis effects is a challenge for empirical research, as they usually go hand-in-hand. In this paper, we exploit a policy reform that led to a wholesale funding shortfall in only one market during an otherwise tranquil period to study the dynamics of funding dry-ups.

We first provide evidence of a new channel through which funding dry-ups spill over from one funding market to others. When banks face a funding shortage in one market, they substitute into other sources of funding, intensifying competition. As a result, banks that are not directly affected by the original funding dry-up might nevertheless face a funding squeeze.

We show that these spillovers also affect bank lending and performance. Banks that ultimately suffer from a funding dry-up indirectly through spillovers lend relatively less despite charging a lower price. This points to lower demand for loans from these banks rather than a reduction of loan supply by banks. As these banks' competitiveness and profit margins decline, also their stocks underperform. Our results suggest that banks' competitiveness in funding markets affect their competitiveness in lending markets.

We use the US money market fund (MMF) reform that was implemented in October 2016 as the policy event in a difference-in-differences framework. The reform was adopted in order to curb the run-prone nature of MMFs. In response to the reform, fund families converted prime funds into government funds, which, in effect, replaced the provision of unsecured funding to banks with buying government securities. The reform resulted in an aggregate loss of around $ 350 billion in unsecured dollar funding for global banks with MMF exposure.

The reform constitutes close to an ideal setting to study channels of spillovers from a funding squeeze. In addition to taking place during an otherwise tranquil period for financial markets, it directly affected only banks that actively borrow from MMFs (MMF banks). This allows for a clean distinction between MMF banks and non-MMF banks in our study, where the impact of the reform on non-MMF banks is only through spillovers.

We combine three granular datasets to study spillovers in funding markets and their effect on bank lending. First, we identify banks that suffered a loss in dollar funding due to the reform by using transaction-level data from the regulatory filings of US MMFs. Second, we use a unique and granular dataset from one of the largest corporate deposit trading platforms located in Europe. In the platform, firms auction deposits and banks bid for them. The dataset contains bid-level information on deposit auctions in various currencies, with the largest transaction volumes in dollars, euros and pounds. We focus on transactions in dollars since the reform induced a wholesale dollar funding shortage, but also do placebo tests using other currencies. This helps us to isolate and identify the effect of the reform. Third, we use data on syndicated loans to study changes in the lending behavior of banks in our sample.

The terms of funding that banks obtain from MMFs versus corporate depositors vary substantially. This is reflected in the segmentation of markets in the pre-reform period. MMF funding is

on average more expensive, but it is also more stable. In our sample, some banks are active in both markets, while others only participate in the corporate deposit market.[1] We take this as evidence that banks active in both markets have a stronger preference for stable funding. We also differentiate between corporate depositors and divide them into two categories: stable funding providers and others. We present evidence that banks active in both markets are also the ones preferred by firms, especially by stable funding providers in the pre-reform period.

The inferences we make about the ranking of preferences by banks and firms lead naturally to hypotheses that we test using the MMF reform as an exogenous funding shock. After the implementation of the reform, MMF banks lost unsecured funding from MMFs, their preferred source of funding. We conjecture that after the MMF reform, these banks would resort to less preferred funding sources such as corporate deposits. Since these banks are also preferred by firms, this would mean either a loss of deposits or a rise in deposit rates for non-MMF banks due to intensified competition in the corporate deposit market. Moreover, we expect that these effects are stronger for funding offered by stable funding providers.

We show that after the reform, non-MMF banks pay higher deposit rates in order to retain their corporate deposit funding. Moreover, MMF banks attract stable funding providers away from non-MMF banks. For the latter group of banks, the probability of winning an auction with stable funding providers decreases after the reform. They are forced to form new relationships with less stable funding providers by bidding higher prices. As a robustness check, we show that all these effects only apply to dollar deposits – there is no effect on pound deposits. This suggest that the effect is driven by spillovers due to the reform rather than any unobserved heterogeneity between the two groups of banks.

Finally, we focus on the implications of those spillovers in wholesale funding markets on bank lending, riskiness and performance. In the aftermath of the reform, the lending rates that non-MMF banks charge, controlling for loan characteristics, are lower relative to MMF banks. So is their lending in dollars. This suggests lower demand for loans made by non-MMF banks. On the liability side, they pay more for funding, and at the same time their lending mark-ups decrease, leading to a relative decline in profit margins. Taken together, the results point to a loss of competitiveness in lending markets driven by the loss of competitiveness in funding markets.

Consistent with the relative decrease in profitability of non-MMF banks, we show that over a 3-month horizon, stocks of MMF banks outperform those of non-MMF banks by 12-15 percentage points. We test two potential channels of investor expectations leading to this result: First, investors might worry about the ability of non-MMF banks to access dollar funding, causing uncertainty about their riskiness and solvency position. In this case, we would expect the CDS spreads of the two groups of banks to diverge. Second, non-MMF banks might not be able to fully exploit lending

[1] In our difference-in-differences analysis we use this to categorize banks into two groups. We refer to banks that suffered a loss of unsecured funding from MMFs as a direct result of the reform as MMF banks, and to the rest as non-MMF banks. MMF banks are large global banks active in both markets. Non-MMF banks tend to be, on average, smaller European banks active in the corporate deposit market. However, the latter group also includes global and domestic systemically important banks as per the definitions of the Financial Stability Board (FSB) or national supervisors.

opportunities in the future, affecting the stock prices through a reduction of cash flow expectations. We find no evidence of a significant difference in 5-year CDS spreads, lending support to the second channel.

Related literature. Our paper mainly contributes to the literature on stress and spillovers in funding markets. We highlight a new channel of spillovers of funding dry-ups that operates through substitution between markets and intensified competition. To our knowledge, our paper is the first one that studies the linkages between the MMF and corporate deposit funding. Closest to our paper is the paper by Chernenko and Sunderam (2014), which shows that MMF's run on European banks also spilled over to non-European banks in the same market due to frictions in MMF lending. Aldasoro, Ehlers, Eren and McCauley (2017) show evidence of substitution between different sources of wholesale dollar funding by documenting that banks partially replaced the lost MMF funding following the reform with repos and other sources of offshore deposit funding, whereas Aldasoro and Ehlers (2018) document the growing share of dollars non-US banks source outside of the US. Aldasoro, Ehlers and Eren (2019) also show that disruptions in repo markets spill over to FX swap markets, affecting pricing in those markets. In a related paper on corporate deposits, Friedmann (2017) document that during the Great Financial Crisis (GFC), banks bid more often for, and obtained more, unsecured corporate deposits. Other related studies of wholesale markets in distress include studies of markets for certificates of deposits (e.g. Pérignon, Thesmar and Vuillemey, 2018), ABCP markets (e.g. Kacperczyk and Schnabl, 2010; Covitz, Liang and Suarez, 2013; Acharya, Afonso and Kovner, 2017), unsecured interbank markets (e.g. Afonso, Kovner and Schoar, 2011), and repo markets (e.g. Duffie, 2010; Gorton and Metrick, 2012; Krishnamurthy, Nagel and Orlov, 2014).

We also contribute to the literature on the transmission of shocks to bank lending and real outcomes including the literature on the dollar funding and lending of global banks. Dollar funding shocks to non-US global banks act as a powerful mechanism for international spillovers (e.g. Shin, 2012; Ivashina, Scharfstein and Stein, 2015). The closest paper to ours in this literature is by Ivashina, Scharfstein and Stein (2015). They show that in response to a shock to their credit quality, non-US banks lost dollar funding to a greater extent compared to local currency funding due to its wholesale nature. Synthetic borrowing also gets more expensive, and banks cut dollar lending as well. Other related studies on direct spillovers from funding stress include, for example, the Great Depression (e.g. Bernanke, 1983), the property market collapse in Japan (e.g. Peek and Rosengren, 1997; Gan, 2007), the Russian sovereign default (e.g. Schnabl, 2012) or the GFC (e.g. Ivashina and Scharfstein, 2010; Aiyar, 2012; De Haas and Van Horen, 2012). Our findings highlight a mechanism through which a shock in one funding market leads to a reduction in lending for banks only active in other funding markets. These highlight both a direct effect of funding shocks on real outcomes and a potential mechanism for international spillovers. Moreover, the fact that lending volumes and rates both decrease in our setup highlights a channel in which in response to a funding shortage a bank faces, the demand for loans by borrowers from that lender decreases.

The liability structure of banks and their competitiveness in sourcing deposits are increasingly recognized as key reasons for why banks are special (e.g. Drechsler, Savov and Schnabl, 2017; Egan, Lewellen and Sunderam, 2017). While the focus of the literature has been mostly on retail deposits, wholesale funding constitutes an increasingly important part of bank liabilities, especially for dollar banking activities of non-US banks. Two major wholesale funding providers are money market funds (MMFs) and non-financial corporate firms. In a paper that is a close companion to ours, Aldasoro, Ehlers and Eren (2019) study competition in the MMF sector and the implications for pricing of both repo and unsecured funding for global banks. Data unavailability in corporate deposit markets has previously hindered the study of corporate deposit markets. We use a novel, granular dataset on corporate deposits to study competition for corporate deposits, the nature of market segmentation for banks between MMF and corporate deposit funding and linkages between the two markets as well as the impact of competition in wholesale funding markets on lending markets.

Our paper is further related to the literature on price competition for deposits, which goes back to the seminal work of Stiglitz and Weiss (1981) and Diamond (1984) and also closely related to Stahl (1988) and Yanelle (1997), who theoretically show that competitiveness on the liability and asset sides are interrelated. Our results are in line with these theories.

Finally, our paper contributes to the literature on bank-firm relationships. A large literature studies bank-firm relationships through the lens of banks as lenders. Elyasiani and Goldberg (2004) conduct a comprehensive literature review on relationship lending and conclude that relationships between banks and firms increase funding availability and reduce loan rates. Our results imply that studying relationships through the lens of banks as borrowers might be as important, especially in terms of banks' access to stable funding providers. In a related study of banks as borrowers with a deposit auction setting similar to ours, Friedmann, Imbierowicz, Saunders and Steffen (2017) find that stronger relationships significantly increase the probability of winning a deposit auction. However, this benefit seems to come at a cost, as relationship banks bid higher on average during their observation period.

Roadmap. The rest of the paper is organized as follows: Section II provides some background on MMFs, the US MMF reform and the data sources. Section III provides a description of the two funding markets, outlines the underlying conceptual framework and the empirical design. Section IV presents the empirical results on the impact of the MMF reform on interest rates in the corporate deposit platform. Section V shows the results on the changes in bank-firm relationships in the platform after the reform. Section VI presents empirical results on changes in bank lending, riskiness and stock price performance. Section VII concludes.

II. Institutional background and data

In this section, we provide an institutional background on US MMFs and their interactions with banks. We discuss the details of the 2016 US MMF reform, which forms the basis of our identification strategy. In order to motivate our focus on corporate deposits, we highlight the rising importance of non-financial corporate deposits as a wholesale funding source for banks. Finally, we describe the details of multiple, granular data sources that we rely on for our analysis of competition and spillovers.

A. Money market funds and the MMF reform

US MMFs are open-ended mutual funds that invest in money market instruments such as repos, commercial paper (CP), certificates of deposits (CD), and asset-backed commercial paper (ABCP). With around $3 trillion in assets under management, MMFs are an important source of funding for banks, as well as an attractive investment for a range of investors. Since their inception in the 1970s and up to the GFC, they were perceived as an investment as safe as bank deposits, but able to provide better returns. The ability to keep their net asset values (NAV) at $1 per share was historically an important factor underpinning this perception, since MMF investments are not insured. However, when the oldest MMF (Reserve Primary Fund) "broke the buck" in the aftermath of the Lehman Brothers collapse, this perception vanished as investors ran to redeem their shares, bringing about the collapse of the fund. This in turn led to additional investor redemptions in other funds (e.g. Schmidt, Timmermann and Wermers, 2016; Kacperczyk and Schnabl, 2013). The run-prone nature of MMFs was again highlighted during the European sovereign debt crisis (Chernenko and Sunderam, 2014).

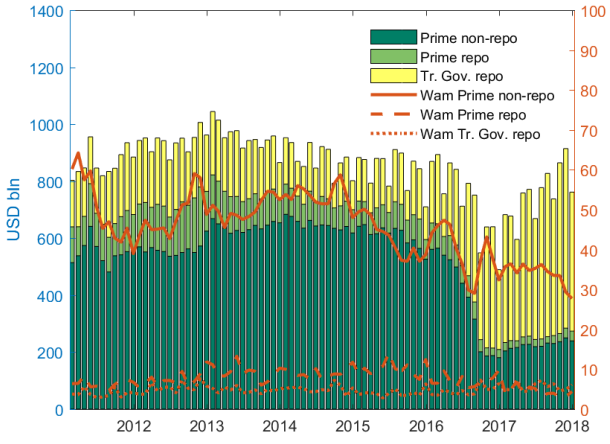
The revealed fragility of MMFs prompted the Securities and Exchange Commission (SEC) to respond by adjusting the regulation governing MMFs, known as Rule 2a-7 of the Investment Company Act of 1940. After requirements to invest in even higher quality assets with shorter maturities adopted in 2010, an important revision of Rule 2a-7 was approved by the SEC in July 2014. The reform came into effect fully in October 14, 2016, but had earlier compliance dates for parts of the reform package starting on April 14, 2016. Due to the short-term nature of funding in this market, much of the adjustment happened closer to the date of full implementation (Figure 1).

With the primary goal of addressing the risk of runs on MMFs, the reform required institutional prime funds and municipal funds to switch from a stable to a floating NAV calculation and introduced redemption gates and fees at the discretion of the fund. This finally led to the conversion of many prime funds to government funds. While prime funds can invest in CPs, CDs, repos and other types of bank debt, government fund are restricted to holding government securities or financing banks only through repos back by government securities.

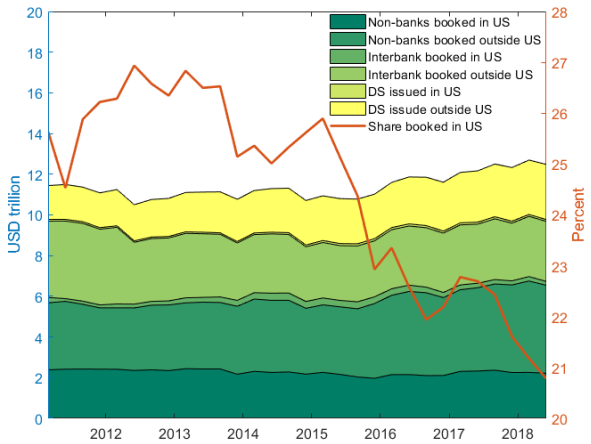
The reform represented an important negative unsecured dollar funding supply shock to global non-US banks, which heavily relied on MMFs for their unsecured dollar funding (Figure 1, left-hand panel). The aggregate funding by MMFs before and after the reform remained largely the same,

Figure 1
The MMF reform and the role of non-bank deposits

(a) Funding by US MMFs to foreign banks



(b) On-balance sheet USD funding of non-US banks



Source: Crane data (left-hand panel), BIS consolidated banking statistics (immediate counterparty basis), debt securities statistics and locational banking statistics (right-hand panel).

but as a result of the fund conversion, the MMF sector has increased their holding of government securities and decreased the unsecured funding provided to banks. This resulted in a drop in unsecured money market funding to non-US banks of around $350 billion between April 2016 and October 2016. The bulk of this adjustment occurred in the last couple of months before the full implementation of the reform.

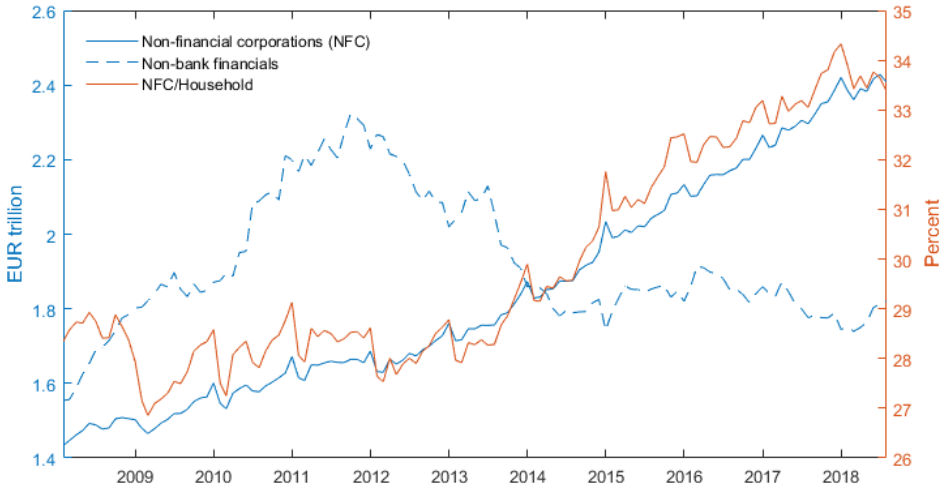
This unsecured dollar funding squeeze did not, however, lead to a dollar funding crisis as in the GFC (McGuire and von Peter, 2012). As documented in Aldasoro, Ehlers, Eren and McCauley (2017), non-US banks were able to replace the loss of non-bank dollar deposits in the US with non-bank dollar deposits elsewhere (Figure 1, right-hand panel). One of these substitutes is corporate deposit funding from outside US, an increasingly important source of wholesale funding for banks globally.

B. Corporate Deposits

Non-financial corporate deposits account for an increasing share of funding for banks. To motivate the rising importance of non-financial corporate deposits, in Figure 2, we present selected liability positions of euro area banks. We focus on euro area banks due to availability of disaggregated data that label non-financial corporate deposits as a separate balance sheet item.

Over a period of ten years from 2008 to 2018, non-financial corporate deposits have risen substantially by close to €1 trillion to about €2.4 trillion as of July 2018. Starting in early 2013, non-financial corporate deposits have not only accelerated growth in absolute terms, but have also gained importance relative to household deposits. This occurred simultaneously with an absolute decline in funding coming from non-bank financial institutions, e.g., MMFs.

Figure 2
Deposit liabilities of euro area banks



Source: ECB Statistical Data Warehouse, Balance Sheet Items, Euro area counterparties.

C. Data

We draw on various data sources. First, we use a rich dataset on transaction-level MMF holdings coming from their regulatory filings to the SEC, in order to identify and quantify the initial funding shock to the MMF banks. Second, we make use of a novel and granular dataset of corporate deposit transactions at auction bid level to quantify spillovers and study competition among banks for funding. Third, we obtain data on syndicated loans to analyze the impact of wholesale funding competition and spillovers on lending competition among the banks in our sample. We also use other data sources such as balance sheet information for banks and market data. We describe all data sources in detail below.

MMF data

We calculate banks' initial funding loss using month-end holdings of MMFs as reported in their regulatory filings to the SEC (SEC N-MFP forms), collected by Crane Data. Crane Data reports detailed information on the instruments MMFs invest in, such as transaction amounts, prices, remaining maturities and other important contract characteristics.

We restrict the sample to the unsecured funding instruments through which banks borrow from MMFs, namely CDs, CPs and ABCPs, as this is the market that was negatively affected by the reform (Aldasoro, Ehlers and Eren, 2019). We link the contract-level information to the parent institution of the issuer, and aggregate funding from the three instruments at the bank-month level.

Corporate deposits data

The core of our analysis builds on a unique and comprehensive dataset of corporate deposit auctions on one of the largest electronic trading platforms by volume in Europe.

On this platform, non-financial corporate firms offer their excess liquidity in a certain currency, choosing the size and maturity.[2] There are no restrictions for the deposit-providing firms on deposit amounts or maturities traded on the platform. Banks can trade with firms they have a trading agreement with and can bid in auctions by quoting an interest rate (provided they have been invited to provide a quote by the firm). Interest rates are quoted using an actual/360 day count convention and transactions are settled on the same day. The bidding period lasts for two minutes by default and banks can adjust their quotes anytime during this period. Banks cannot see the quote of other banks, hence initial quotes and adjustments should not be influenced by the behavior and risk evaluation of other bidders. After the bidding period, firms choose a winning bid out of the last quotes of all bidding banks at their own discretion, i.e., there are no rules on how to select the winning bid.

The dataset contains all bids (including adjustments) placed by different banks during the deposit auctions. Banks participating in auctions are identified by name. This allows us to match bank information to other datasets. Deposit providing firms are anonymous, but have a unique identifier. This allows us to track firms over time.

We mainly focus on dollar deposits as the MMF reform represented a negative shock to dollar funding, but also conduct placebo tests using other currencies. In 2016, transactions denominated in dollars, euros, and pounds respectively had a daily turnover of around 1.5 billion dollars, 2.7 billion euros, and 0.8 billion pounds, and a median transaction size of about 23 million dollars, 50 million euros, and 20 million pounds.[3] In 2016, banks directly affected by the MMF reform captured slightly more than 70% of this market, whereas unaffected banks accounted for the rest. On average, each bank obtains $610 million in dollar funding in 15 transactions per month, which aggregates to a monthly average transaction volume of 29 billion dollars and on average 690 transactions per month.

It is important to note that even though the platform that we study is a large one, it only constitutes a small share of the entire dollar corporate deposit market. Therefore, while our results apply to this platform, any broader conclusions rely on the assumption that it is a representative sample of the global corporate deposit market.

Lending data

We use syndicated loan data from Dealogic for the analysis of lending volumes and prices. Dealogic provides detailed data on bank syndicated loan origination in various currencies around the globe.

The dataset includes information on the borrowing companies, the syndicate banks as well as their individual role (e.g., arranger vs. participant), the currency, and the loan tranche value.

[2]Note that the platform is less prone to supply-side confounding factors as funding supply is purely determined by firms' excess liquidity. Figure A.1 in Appendix A presents the distribution of notional dollar amounts and transactions in dollars for our main sample.

[3]We do not use auctions for euro deposits as policy developments in the euro area during our sample periods contains potentially confounding factors.

Some important loan details, however, are not available for all loans. Loan spreads paid above interbank rates (such as LIBOR) and maturities are only available for around 50% of the loans. Exact shares of the loan tranche volume per bank are included for around 25% of the loans. We extrapolate the available allocation information of loan tranche volumes to loans without such details. In particular, we use the average monthly distribution of loan shares on arranger and participant banks per currency to allocate the loan shares of loans originated in the same month and denominated in the same currency.

After the data preparation and before reducing the sample to banks active on the deposit trading platform, we obtain about 90,000 loan observations for the period of six months before and six months after the US MMF reform, denominated in 42 currencies – around half of the observations are denominated in dollars. The average dollar-denominated loan has a value of $70 million, a spread of 250 basis points over LIBOR, and 4.5 years maturity.

Bank characteristics and market data

We include additional bank balance sheet and income statement information to the corporate deposits dataset from S&P Global Market Intelligence (formerly SNL Financial), which is at annual frequency for most banks in the sample. We also obtain daily stock prices for listed banks from S&P Global Market Intelligence. Daily pricing data of five-year bank credit default swaps (CDS) on senior unsecured debt are retrieved from Markit.

III. Empirical design

In this section, we present summary data on the characteristics of the funding markets, banks, and the interactions between funding providers and banks, in particular with regards to transaction volumes, maturities, and prices. We use these data to lay out the conceptual framework we use to develop hypotheses. We also discuss the details of the empirical design we use to test them.

A. Market segmentation, and characteristics of MMF and corporate deposit funding

The two markets we study are segmented. Figure 3 illustrates the nature of this segmentation. In our dataset, there are some banks that are active in both markets (Bank A). Other banks do not have any funding relationships with US MMFs, but borrow dollars in the corporate deposit market (Bank B).

Figure 3
Funding market segmentation

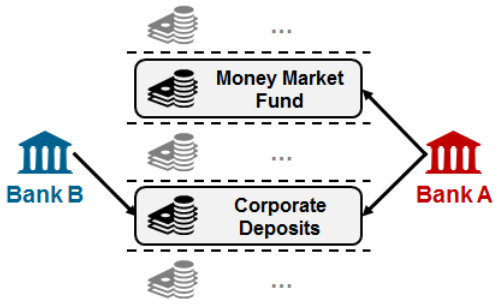


Table I describes key characteristics of the contracts that banks have with MMFs and corporate deposit providers. A key difference between the two markets is that funding from MMFs has two desired features for banks that are active in both markets. First, the average size of a transaction with MMFs is more than twice as large as that from corporate deposits. Second, and perhaps more importantly, the average maturity of MMF funding exceeds that of corporate deposits by a wide margin. However, partly reflecting the longer maturities, the rates for MMF funding are higher than for corporate deposits.

Table I
Key characteristics of markets from October 1, 2015 to March 31, 2016

	US MMFs	Corporate Deposits	
	Bank type A	Bank type A	Bank type B
Avg. transaction [USD mn]	105.31	50.09	42.81
Avg. maturity [days]	45.85	8.70	8.31
Avg. rate [bps]	51.44	26.21	32.68

Source: Crane Data and corporate deposit data.

Notes: Bank type A refers to banks active on both markets and bank type B to banks not active on US MMF markets, as illustrated in Figure 3. US MMF transactions consider only banks active in both markets, i.e. type A banks. In line with corporate deposits characteristics, for the MMF market only certificates of deposits of are considered.

In order to shed light on the reasons for the observed segmentation in more detail, we explore the difference between the two markets by running the regression in Equation 1 on contract-level data. We regress the rate paid for unsecured MMF funding and corporate deposits on interactions between contract maturity, size, and whether the funding comes from MMFs or corporate deposits.

$$\begin{aligned} Rate_{ijct} = \alpha(+\alpha_i + \alpha_t + \alpha_{it}) + MMF_j + maturity_{ijct} + maturity_{ijct} * MMF_j \\ + transaction\_size_{ijct} + transaction\_size_{ijct} * MMF_j \\ + maturity_{ijct} * transaction\_size_{ijct} \\ + maturity_{ijct} * transaction\_size_{ijct} * MMF_j + \epsilon_{ijct} \end{aligned} \tag{1}$$

The dependent variable is the interest rate paid by bank i to either MMF or corporate funding

provider j in contract c at time t in basis points. $maturity_{ijct}$ and $transaction\_size_{ijct}$ denote the maturity and transaction size of the contract respectively. MMF_j is a dummy variable equal to 1 if the funding provider is a MMF, and zero if the funding provider is a corporate firm. α_i, α_t, and α_{it} denote fixed effects at the bank, month, and bank-month level. The sample consists of all transactions from October 1, 2015 to March 31, 2016 of banks active in both the corporate deposit platform and US MMF markets. The time period is before the start of the implementation of the US MMF reform in order to capture market characteristics prior to the regulatory intervention. In order to make the comparison between the two funding markets as meaningful as possible, only certificates of deposits of US MMFs are considered for this analysis.

Table II

The determinants of the price of funding with US MMFs and corporate firms

	(1)	(2)	(3)	(4)	(5)
MMF_j	21.6329***	22.1948***	20.0099***	20.8606***	20.9239***
	(2.1065)	(2.1222)	(2.3068)	(2.2985)	(2.3149)
$maturity_{ijct}$	0.2261***	0.2116***	0.2385***	0.2298***	0.2281***
	(0.0311)	(0.0297)	(0.0294)	(0.0278)	(0.0291)
$maturity_{ijct} * MMF_j$	-0.0770**	-0.0774**	-0.0785**	-0.0852***	-0.0854***
	(0.0320)	(0.0311)	(0.0294)	(0.0276)	(0.0281)
$transaction\_size_{ijct}$	0.0045	0.0229***	0.0068	0.0237**	0.0229**
	(0.0109)	(0.0067)	(0.0129)	(0.0090)	(0.0092)
$transaction\_size_{ijct} * MMF_j$	-0.0119	-0.0298***	-0.0129	-0.0296***	-0.0287***
	(0.0116)	(0.0074)	(0.0135)	(0.0098)	(0.0101)
$maturity_{ijct} * transaction\_size_{ijct}$	0.0027***	0.0012**	0.0027***	0.0012***	0.0013***
	(0.0004)	(0.0005)	(0.0004)	(0.0004)	(0.0004)
$maturity_{ijct} * transaction\_size_{ijct} * MMF_j$	-0.0026***	-0.0011**	-0.0026***	-0.0011**	-0.0012***
	(0.0005)	(0.0005)	(0.0004)	(0.0004)	(0.0004)
N	19,846	19,846	19,846	19,846	19,845
R^2	0.3092	0.6035	0.3477	0.6387	0.6447
Month FE		✓		✓	
Bank FE			✓	✓	
Bank-month FE					✓

Notes: OLS regressions at the contract level as in Equation 1. The dependent variable is the interest rate paid by bank i to either MMF or corporate funding provider j in contract c at time t in basis points. $maturity_{ijct}$ and $transaction\_size_{ijct}$ denote the maturity and transaction size of the contract respectively. MMF_j is a dummy variable equal to 1 if the funding provider is an MMF, and zero otherwise. The sample consists of all transactions of banks active in both the corporate deposit platform and US MMF markets, from October 1, 2015 to March 31, 2016. The time period is before the start of the implementation of the US MMF reform in order to capture the market characteristic prior to the regulatory intervention. Only certificates of deposits of US MMFs are considered for the analysis. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Table II highlights a trade-off for banks choosing between MMF funding and corporate deposit funding. Banks pay on average more when transacting with MMFs. However, for longer maturities and/or larger transaction sizes, banks can pay marginally less for funding if their counterparties are MMFs. Since banks of type A in Figure 3 did have large total volumes of transactions with MMFs, we take this as an indication that they have a preference for stable funding. At the same time, banks of type B can get access to cheaper short-term funding from the corporate deposit market as long as they do not have a preference to obtain the longer maturity and larger transaction size available through MMFs. These results form a key part of our framework and subsequent analysis.

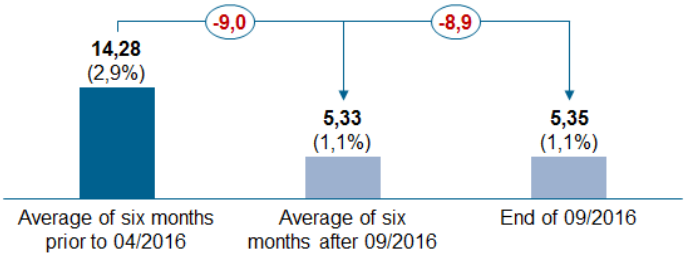
B. *Identification strategy and descriptive statistics*

Our identification strategy relies on a difference-in-differences analysis. We match the MMF data with the corporate deposit data using bank names. The matched sample allows us to categorize banks active on the platform according to their funding loss from MMFs during the reform implementation. We categorize banks as *MMF* if they suffered a funding loss in the six months after full reform implementation in October 2016 relative to the six months up to the start of reform implementation in April 2016. The classification of MMF banks as such is conditional on these banks having funding exposures to MMFs in the three months prior to April 2016.[4] Banks not fulfilling these conditions are classified as *non-MMF*.[5]

Figure 4 presents descriptive statistics on the funding loss from MMFs for MMF banks. These banks had an average funding exposure of $14.3 billion in the six months prior to April 2016 (close to 3% of total assets). This amount dropped to $5.3 billion in the six months post reform implementation period, which implies an average funding loss of about $9 billion.[6]

Figure 4

MMF banks' US MMF funding exposure in $ billions (% of total assets)



Source: authors' calculations using Crane Data for banks active on the corporate deposit trading platform.

Our final sample comprises a total of 55 banks and 89 deposit providing firms executing 4,319 transactions on the platform. Of these banks, 31 are identified as MMF and 24 as non-MMF banks. From the 24 banks in the latter group, 3 are in the MMF sample, but have a negligible exposure to MMFs. Our sample consists of banks from 19 different countries (see Table A.1 in Appendix A). Banks within a country are typically all either in one group or the other, with the exception of those jurisdictions where the largest banks are headquartered (such as France, Germany, Spain, Switzerland and the United Kingdom).

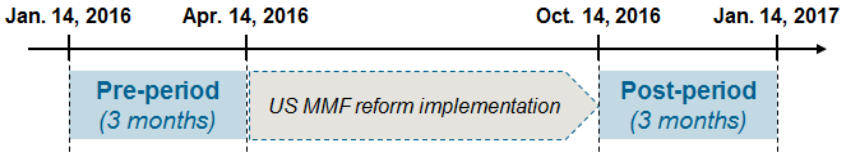
[4]The applied funding loss definition results in the same classification as using the point in time funding loss as of end of September 2016 – i.e., the last pre-reform implementation observation – except for two banks. This point in time consideration captures one-time outliers that do not correctly reflect the actual funding substitution need and therefore the average of six months after the reform implementation is the better comparison. Similarly, using three instead of six months before and after the reform implementation for measuring the funding loss only reclassifies one bank and looking into the development of MMF exposures again reveals that this is driven by an uninformative outlier. In our view, using the six-month window reflects better the reliance of banks on funding from MMFs, as well as the loss of funding as a consequence of the MMF reform.

[5]One could alternatively use the intention to treat rather the actual treatment of a funding loss to classify banks. Using an intention to treat dummy would only reclassify one bank with a relevant MMF exposure prior to the reform, which does not change results.

[6]The same number is obtained when looking at the funding these banks got in September 2016.

The main analyses are based on an observation period of three months before the first MMF reform compliance date on April 14, 2016 ("pre" period) and three months after the full implementation of the reform on October 14, 2016 ("post" period) as depicted in Figure 5.

Figure 5
Timeline of empirical setup



As shown in Table III, it is striking that in the corporate deposit platform the group of banks that seems to be negatively affected by the reform are the non-MMF banks, for which the US MMF reform had no first order impact. The non-MMF banks pay higher prices after the reform and yet lose market share in aggregate. Moreover, they bid more often, yet enter in fewer transactions.

In our subsequent analysis, we argue that the spillover channel could explain this observation. In particular, we use granular data to analyze the spillover effects of the US MMF reform into the corporate deposit market through competitive pressures arising from increased presence of MMF banks in this market using a difference-in-differences framework.

Table III
Summary statistics dollar denominated auctions by bank group and period

Bank group	MMF banks		non-MMF banks		All banks	
Period	pre	post	pre	post	pre	post
No. bids	4,386	4,264	1,314	1,457	5,700	5,721
No. trans.	1,417	1,617	614	536	2,031	2,153
No. banks	29	31	20	20	49	51
No. firms	56	56	44	40	70	71
thereof new	-	*15*	-	*15*	-	*26*
Avg. notional	45.86	42.15	36.90	37.19	43.15	40.92
Avg. maturity	10.55	14.62	8.01	10.59	9.78	13.61
Avg. spread	-2.03	-0.84	3.18	9.62	-0.45	1.77
Market share	74.15	77.37	25.85	22.63	-	-

Notes: Summary statistics for corporate deposit auctions denominated in dollars. Bank groups and pre-reform/post-reform periods as specified in Section III.B. *No. bids* is the total number of bids. *No. trans.* is the number of transactions. *No. banks* is the number of banks active in transactions. *No. firms* is the number of deposit providing firms active in transactions. *thereof new* denotes the number of firms having their very first transaction with one of the active banks in the post period. *Avg. notional* is the average notional deposit amount of transactions in $ millions. *Avg. maturity* is the average maturity of transactions in days. *Avg. spread* is the deposit spread (deposit interest rate - interbank benchmark rate of comparable maturity) in basis points. *Market share* denotes aggregate share of total notional deposit amount on the trading platform in percentages for each group.

Next, we show aggregate data on balance sheets. Table IV presents balance sheet information for both groups for the pre- and post-reform periods.[7] Banks in the two groups differ along some

[7]As we only have year-end data for some banks, we approximate the pre-reform period as end-2015 and the post-reform period as end-2016.

dimensions. MMF banks are on average larger, more leveraged, with a larger share of loans and a smaller deposit-to-assets ratio compared to non-MMF banks.

Once again, similar to the patterns in corporate deposits, non-MMF banks seem to have been impacted negatively also on the asset side. The most notable changes between the pre and post reform are the relative increase in loans for MMF banks and a reduction for non-MMF banks. In particular, what stands out is a decline in the net interest income revenue share for non-MMF banks.

In our subsequent analysis, we use syndicated loan data in order to establish whether negative spillovers on the funding side affected the lending of non-MMF banks negatively following the reform, again using a difference-in-differences framework.

Table IV

Balance sheet characteristics by bank group, pre and post reform

Bank group	MMF		non-MMF	
Period (year-end)	2015	2016	2015	2016
Total assets [USD bn]	1,022	1,043	307	308
Leverage (total assets/equity)	18.0	17.9	15.1	14.6
NII revenue share [%]	55.3	56.0	55.2	47.6
Loans-to-deposits [%]	106.1	107.6	103.9	100.8
Loans-to-total assets [%]	48.8	49.4	46.7	45.7
Deposits-to-total assets [%]	47.6	48.3	49.3	50.2

Source: S&P Global Market Intelligence; authors' calculations.

IV. The MMF reform and interest rates on corporate deposits

In this section, we show that a negative funding shock in one market spills over to other markets through intensified competition. Somewhat surprisingly, it is non-MMF banks who ultimately suffer the most from the MMF reform funding shock. Following the reform, these banks had to increase their offered deposit interest rate bids to retain funding in response to intensified competition.

We proceed as follows. We first present evidence that there were no significant differences between the deposit spreads paid by MMF and non-MMF banks prior to the implementation of the reform, while the divergence took place following the reform. We then show this formally in a difference-in-differences framework. Finally, we compare the interest rates in dollar versus pound denominated deposits paid by the two groups of banks and find that the results only apply to dollar-denominated funding, suggesting that the results are driven by the reform.

A. Trends in deposits spreads of MMF and non-MMF banks

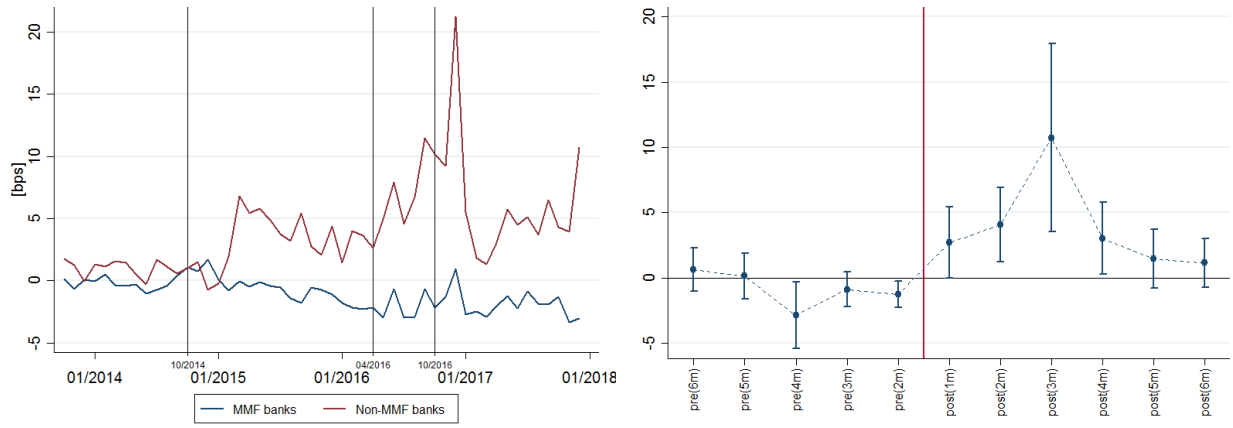
The cost of wholesale corporate dollar deposits for MMF and non-MMF banks started to diverge around the MMF reform. The left panel of Figure 6 plots the average monthly deposit spread for

each group for dollar denominated deposits.[8] These trends were roughly similar between the two groups of banks prior to the first implementation date in April 2016.[9]

The parallel trends assumption is evaluated more formally in the right panel of Figure 6, where we plot the estimated coefficients and confidence bands of a regression of deposit spreads on an interaction between a dummy indicator for non-MMF banks and a dummy indicator for the six months pre and post reform.[10] Hence, these coefficients capture the difference between the prices paid by the two groups of banks in the respective months. In the run-up to the reform, these coefficients are statistically not significantly different from zero, whereas they move to positive territory post reform.

Figure 6

Monthly average deposit spread and parallel trend test visualization



Left panel: The deposit spread is defined as the deposit interest rate minus the USD LIBOR rate of comparable maturity, in basis points. Monthly average deposit spread per bank group, i.e. treated and non-treated banks.
Right panel: Point estimates for the coefficients of $pre/post \cdot nonMMF$ interactions from Table B.2, column (5) and the 90% confidence bands. The vertical red line denotes the MMF reform date.

B. *Identifying spillovers: deposit spreads before and after the MMF reform*

To assess the economic and statistical significance of the divergence in deposit spreads paid by MMF and non-MMF banks, and to identify spillovers more formally, we run the following regression based on transaction-level data, i.e., using information only on the winning bids in the corporate deposit auctions:

$$\begin{aligned} Spread_{ijat} = \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot post_t \\ + \beta_3 \cdot YearEnd_t + \beta_4 \cdot YearEnd_t \cdot nonMMF_i + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ijat} \end{aligned} \tag{2}$$

[8] The deposit spread is defined as the deposit interest rate of the transaction minus the interbank benchmark rate, i.e., USD LIBOR rates for dollar denominated transactions of comparable maturities in basis points.

[9] The initial divergence of deposit spreads at the beginning of 2015 could also be driven by the adoption of the law in October 2014. We show in Appendix B that this difference is not statistically significant.

[10] The estimation equation includes bank and auction controls, as well bank fixed effects and firm-month fixed effects. The table for this regression can be found in Appendix B.

$Spread_{ijat}$ describes the deposit spread paid by bank i to firm j in auction a at time t. $nonMMF_i$ denotes a dummy variable that equals 1 if bank i is not affected by the money market fund reform (i.e. non-MMF bank) and 0 otherwise. $post_t$ is a dummy variable equal to 1 if the transaction occurs in the post reform period and 0 otherwise. $\boldsymbol{X}_a$ is a vector of transaction-specific control variables (maturity and the logarithm of notional amounts). $\boldsymbol{Y}_{i(t-1year)}$ is a vector of bank balance sheet control variables lagged by one year, and contains bank size (measured as logarithm of total assets), bank leverage (defined as total assets over total equity), and the share of net interest income of total revenues as a business model indicator. As the variation in the regression setting is at the transaction-level, we are able to exploit within-bank variation and include bank fixed effects α_i that absorb bank-specific time-invariant characteristics. α_{jt} are $firm \times time$ fixed effects that absorb time-varying firm-specific characteristics and all common, time-specific variation, thereby controlling for any supply effects. We also control for potential confounding year-end pricing effects by including a year-end dummy. The main coefficient of interest is β_2, capturing the difference-in-differences effect $nonMMF_i \cdot post_t$.

Results of the regression on deposit spreads are presented in Table V. In column (1), we control for several transaction and bank characteristics and absorb $firm \times time$ variation via fixed effects. In the most saturated specifications (columns (2)-(5)), we additionally absorb time-invariant bank characteristics using fixed effects and gradually add controls for deposit transaction characteristics and time-varying bank controls.

In line with Figure 6, we find no significant difference in the deposit spread that MMF banks pay compared to non-MMF banks prior to the reform conditional on the included controls. However, we observe a strong premium paid by non-MMF banks after the reform: These banks have to pay between 6 and 9 basis points more to obtain dollar deposits compared to MMF banks, which is not only statistically significant, but also economically large. Non-MMF banks have to increase their deposit rates by 20-30% (relative to their pre-reform average) to retain their corporate deposit funding levels.[11] The results are robust to varying the period lengths and moving pre- and post-reform periods away from April and October, respectively, for reasonably large distances. Furthermore, they are also confirmed by period placebo tests.[12]

Results could be driven by selection effects in bank-firm pairs. This would occur if some firms that demand a higher spread trade only with non-MMF banks and these banks are not able to trade with low spread-demanding firms. In order to rule out this selection concern, we re-run the regressions on a reduced sample, where we only consider firms that interact at least once with a bank from either group of banks. The results for the most saturated specification, similar to the one in column (5), are shown in column (6) of Table V and document that selection is not driving our results. The point estimate as well as the standard error of the interaction variable in the reduced sample model are virtually unchanged.

[11] The difference-in-difference coefficient only reflects a relative change of non-MMF to MMF banks. However, Figure 6 indicates a rather stable time trend for MMF banks regarding deposit rates, why the relative premium of non-MMF banks can be interpreted as a deposit rate mark-up.

[12] See Online Appendix OA and Online Appendix OB for details.

Table V

Non-MMF banks pay more for dollar deposits after the MMF reform

	(1)	(2)	(3)	(4)	(5)	(6)
$nonMMF_i$	2.3866					
	(1.9544)					
$nonMMF_i * post_t$	6.5272**	9.0780***	9.0459***	9.0499***	8.8747***	8.4618***
	(2.7123)	(2.5854)	(2.5302)	(2.5331)	(2.5367)	(2.4756)
$YearEnd_t$	61.6920	63.3683	63.4160	63.4142	63.4070	-1.6631
	(64.9287)	(65.3295)	(65.3238)	(65.3273)	(65.3411)	(4.1098)
$YearEnd_t * nonMMF_i$	121.4400	118.4636	118.7402	118.7438	118.8540	183.8017***
	(94.6347)	(92.4322)	(92.3171)	(92.3259)	(92.4369)	(65.4437)
$Notional_a$			0.4632	0.4630	0.4445	0.3591
			(0.3241)	(0.3242)	(0.3244)	(0.3811)
$Maturity_a$			0.0908**	0.0909**	0.0901**	0.0887**
			(0.0354)	(0.0354)	(0.0353)	(0.0366)
$Size_{it-1}$	-1.2512	10.2497	6.9257	8.1993	5.5422	5.7859
	(0.9440)	(11.5605)	(11.1794)	(14.6242)	(14.1719)	(14.7037)
$Leverage_{it-1}$				-0.1120	-0.1301	-0.2006
				(0.7498)	(0.5756)	(0.6826)
NII_{it-1}					-0.3995	-0.3873
					(0.2567)	(0.2619)
N	3,873	3,872	3,872	3,872	3,872	3,167
R^2	0.4653	0.5272	0.5322	0.5322	0.5325	0.6505
Firm-month FE	✓	✓	✓	✓	✓	✓
Bank FE		✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 2. The dependent variable is the deposit spread $Spread_{ijat}$ defined as the deposit interest rate minus USD LIBOR rate of comparable maturity (in basis points), payed by bank i to firm j in auction a at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is not directly affected by the MMF reform and $post_t$ a dummy variable equal to 1 in the post MMF reform period. $Notional_a$ stands for the logarithm of the notional deposit amount, $Maturity_a$ for the remaining time (in days) until the funding matures, $Size_{it}$ stands for the logarithm of bank total assets, $Leverage_{it}$ for total assets over equity, NII_{it} for the share of net interest income of bank's total revenue. In column (6), we use only a reduced sample of firms that interact at least once with banks from either group of MMF banks and non-MMF banks. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Bank heterogeneity could also be driving results. Banks face varying degrees of financial frictions that determine their access to wholesale funding and capability of substitution. Table B.3 in Appendix B shows that bank heterogeneity (in terms of size, leverage and net interest income importance) is not driving our results.

C. Placebo test: Dollar versus pound denominated deposit spreads

It is possible that for reasons unrelated to the US MMF reform, non-MMF banks had higher funding costs during our sample period. To rule out this concern, we compare the dollar results to currencies that are not impacted by the US MMF reform. The platform provides us with a similarly diversified dataset in terms of participating MMF and non-MMF banks as well as sufficiently many transactions for euro and pound denominated auctions. We focus on pound denominated auctions as euro denominated money market products are strongly influenced by negative deposit facility

rates and quantitative easing programs by the ECB during our sample period.[13]

We add pound denominated deposit auctions to the sample and interact our main variables of interest in Equation 2 with a dollar dummy variable to measure the differential effect of the US MMF reform on dollar denominated transactions relative to pound denominated transactions. If the effect that we identify in Table V originates from the US MMF reform, pound denominated auctions would not be affected and we should observe a significantly different effect between dollar denominated and pound denominated transactions in the aftermath of the MMF reform. We estimate the following difference-in-differences-in-differences equation:

$$\begin{aligned} Spread_{ijact} = {} & \alpha_c + \alpha_{jt} + (\alpha_i + \alpha_{ct}+)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot Dollar_a \\ & + \beta_3 \cdot nonMMF_i \cdot post_t + \beta_4 \cdot nonMMF_i \cdot post_t \cdot Dollar_a \\ & + \beta_5 \cdot YearEnd_t + \beta_6 \cdot YearEnd_t \cdot Dollar_a + \beta_7 \cdot YearEnd_t \cdot nonMMF_i \\ & + \beta_8 \cdot YearEnd_t \cdot nonMMF_i \cdot Dollar_a + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ijact} \end{aligned} \tag{3}$$

The dependent and control variables remain the same as in Equation 2. The $nonMMF_i$ dummy variable is additionally interacted with a dummy variable $Dollar_a$, which is equal to 1 for transactions denominated in dollars and 0 for transactions in pounds.

Table VI presents the results. We start with the most saturated specification from Table V including additionally currency fixed effects (α_c) and add in the following specifications *currency* $\times$ *time* (α_{ct}) fixed effects to control for time-constant and time-varying characteristics of currencies, respectively. We do not observe any significant trend in the difference between the funding costs for MMF and non-MMF banks in pound denominated transactions. However, non-MMF banks pay a statistically significant and economically large premium after the US MMF reform implementation for dollar transactions compared to pound transactions. The premium of about 8 to over 12 bps is even higher than the premium in the within-currency analysis of dollar transactions only. This finding underscores the notion that the results in Table V reflect the causal effect of intensified competition for wholesale dollar funding arising from the US MMF reform.

[13]The Brexit referendum in June 2016 has a strong impact on pound money market products, which does not leave our platform unaffected either. However, those effects follow directly on the date of the referendum and were washed out already before the full implementation date of the US MMF reform and the beginning of the post-reform period on October 14, 2016.

Table VI

The effect on corporate deposits spreads for non-MMF banks is dollar-specific

	(1)	(2)	(3)	(4)
$nonMMF_i$	-3.8452**	-2.8600*	-2.0215	
	(1.5540)	(1.5044)	(1.4297)	
$nonMMF_i * Dollar_a$	9.0150***	6.8368***	5.0226***	6.1331***
	(1.5241)	(1.6015)	(1.8231)	(1.4659)
$nonMMF_i * post_t$	-2.4178	-2.4816	-4.2215	-3.2121
	(3.3833)	(3.2855)	(3.4781)	(3.0796)
$nonMMF_i * post_t * Dollar_a$	7.9255**	8.3002**	11.6816***	12.1093***
	(3.9043)	(3.8181)	(4.1945)	(3.8299)
N	7,329	7,329	7,326	7,326
R^2	0.7703	0.7710	0.7865	0.7865
Year-end, bank and auction controls	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓
Bank FE				✓
Currency FE		✓		
Currency-month FE			✓	✓

Notes: OLS regressions for Equation 3. The dependent variable is the deposit spread $Spread_{ijact}$ defined as the deposit interest rate minus the LIBOR rate of comparable maturity (in basis points), paid by bank i to firm j in auction a denominated in currency c (i.e. dollar or pound) at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is an non-MMF bank, $post_t$ a dummy variable equal to 1 in the post MMF reform period and $Dollar_a$ a dummy variable that equals 1 for dollar-denominated transactions. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

V. Stable funding providers and bank-firm relationships

In this section, we explore whether intensified competition for corporate deposits also led to changes in bank-firm relationships. Guided by the results in Section III that MMF funding is a more stable source of funding than corporate deposits, we show that MMF banks crowd out non-MMF banks in receiving funding from stable funding providers. We show that the higher rates paid by non-MMF banks are driven by several firm-specific factors determining their quality as funding provider as well as bank-firm relationships.

A. Heterogeneity of funding providers

We exploit the heterogeneity of firms as funding providers in our dataset in order to study the compositional shifts in the corporate deposit platform following the reform. Even though we do not observe the names of firms, we use their identification codes in the dataset to create new measures to categorize firms and also study bank-firm relationships.

Guided by the revealed preference of MMF banks for the stability of MMF funding (i.e., longer maturities and larger transaction sizes), we categorize firms along two dimensions: (i) stability of funding provision and (ii) lot sizes offered. For the first dimension, we introduce an indicator measuring the stability of firms' funding flows on the platform. We define the indicator as the ratio of monthly aggregate notional deposit amount provided by a firm over the average monthly

notional deposit amount of the prior six months in which the firm was active on the platform.[14] Firms are then categorized as "stable funding providers" if their average indicator score during the observation period is larger than or equal to 1, or above the median of all firms. For the second dimension, we divide firms into big and small lot size providers. A firm is classified as big lot size provider if its average transaction size is above the median of all firms' average transaction volumes.[15]

We also build measures of relationships. To evaluate whether MMF banks manage to acquire funds from new firms (the extensive margin) or whether they win more often auctions with firms they already have a relationship with (the intensive margin), we introduce a measure of *new relationship* as a dummy variable that is equal to 1 if the first transaction (determined considering all currencies traded on the platform) between bank i and firm j takes place after April 2016.

Just as banks, firms can also have different preferences in terms of the counterparties they choose to deposit with. On the one hand, as lenders they might simply prefer the highest bidders.[16] At the same time, firms are also borrowers and might prefer to establish relationships with a bank even though it is not the highest bidder. Having beneficial loan conditions or preferred access to international trade finance services might be more important for firms than maximizing deposit conditions on a stand-alone basis. As MMF banks are on average larger and have better access to international markets, it is reasonable that – all else equal – they might be preferred by deposit providing firms as counterparties.

Figure 7 shows the average deposit spread per transaction and the number of executed transactions by firm type and bank group, and provides descriptive evidence for this hypothesis. Already before the reform, funding providers seem to have had a preference for MMF banks. MMF banks paid less, on average, to obtain funding from big and stable funding providers. non-MMF banks could only get favorable terms with smaller and less stable funding providers.

Following the reform, the costs for non-MMF banks rose across the board, and significantly more for stable funding providers, with only a few small and non-stable funding providers offering slightly better conditions. Moreover, MMF banks substituted non-stable funding providers by stable ones through new relationships. Non-treated banks could only maintain the overall level of transactions with stable funding providers by offering significantly higher prices.

B. Regression results

In this section, we test the hypothesis that non-MMF banks were crowded out by MMF banks in the corporate deposit platform for stable funding providers following the reform. We study the probability of winning a deposit auction by bank type in a difference-in-differences framework as

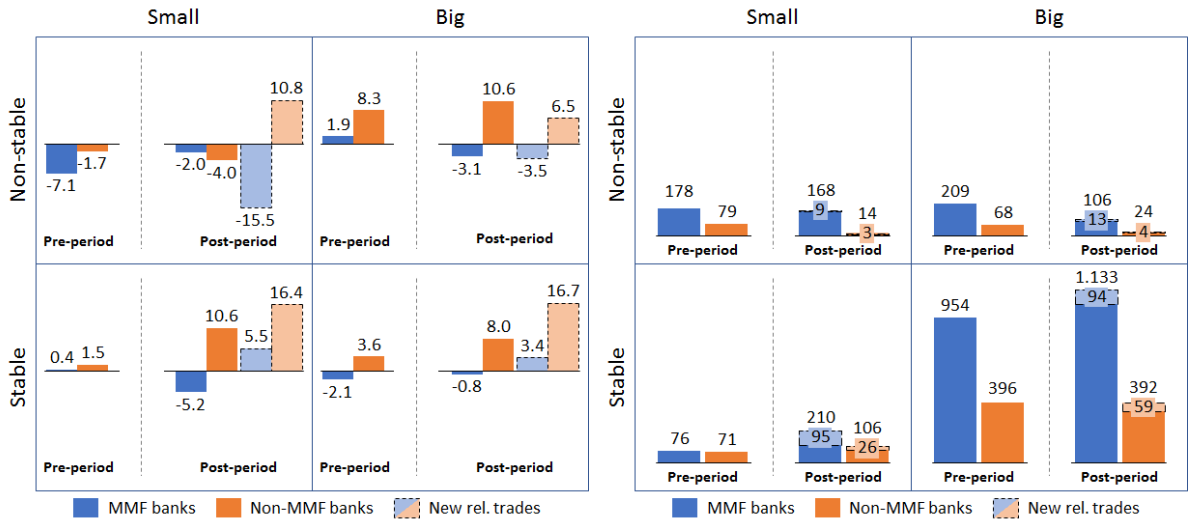
[14] The denominator calculation excludes months without activity in order to compare the current month to an average active month.

[15] Firms' average transaction sizes are calculated using all currencies on the platform. To ensure comparability across currencies, transactions were first translated using daily exchange rates to the same currency.

[16] See Friedmann, Imbierowicz, Saunders and Steffen (2017) who show that the highest quote is most often selected by deposit providers.

Figure 7

Average deposit spread [bps] (left) and number of transactions (right) by firm type



Notes: Only transactions with the respective firm type according to transaction size (small vs. big) and stability of funding provision (stable vs. non-stable) considered in each quadrant. The post-reform period averages distinguish further between trades out of existing and new (i.e. first trade after April 2016) firm-bank relationships.

before. The goal is to assess the role played by bank-firm relationships, firms' stability of funding provision and firms' deposit volumes, beyond the graphical evidence provided in Figure 7. In particular, we estimate the following equation at the *auction quote* level for dollar auctions only:

$$\begin{aligned} WinningBid_{ijabt} = \alpha_{jt} + (\alpha_i + \alpha_{abt}+)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot post_t \\ + \beta_3 \cdot nonMMF_i \cdot post_t \cdot newReln_{ij} + \beta_4 \cdot nonMMF_i \cdot stable_j(big_j) \\ + \beta_5 \cdot nonMMF_i \cdot stable_j(big_j) \cdot post_t \\ + \beta_6 \cdot nonMMF_i \cdot stable_j(big_j) \cdot post_t \cdot newReln_{ij} \\ + \beta_7 \cdot highestQuote_{ab} + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ijabt} \end{aligned} \tag{4}$$

where $WinningBid_{ijabt}$ is a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid quote rank b at time t. Equal quotes are allocated to the same bid quote rank resulting in equally many bid quote ranks as distinct quotes in an auction. We again use the $nonMMF_i$ dummy variable to flag banks not directly affected by the US MMF reform, i.e., the non-MMF banks. $newReln_{ij}$ is a dummy variable for new relationships which is equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. Transactions from new relationships can by definition only take place in the post-reform period, so that the variable can be interpreted as if it was interacted with the post-reform period dummy. $stable_j$ is equal to 1 if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes

of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid quote rank b is the highest quote rank in auction a.

Table VII
Bank-firm relationships after the reform

	(1)	(2)	(3)	(4)	(5)	(6)
$nonMMF_i$	0.0686**		0.0505		-0.1623**	
	(0.0338)		(0.0641)		(0.0752)	
$nonMMF_i * post_t$	-0.0828*	-0.0884**	-0.2958*	-0.2744*	0.1650*	0.1822**
	(0.0423)	(0.0436)	(0.1650)	(0.1585)	(0.0823)	(0.0842)
$nonMMF_i * post_t * newReln_{ij}$	0.1624***	0.1802***	0.7570***	0.7152***	0.1759***	0.1596***
	(0.0334)	(0.0510)	(0.2672)	(0.2655)	(0.0596)	(0.0556)
$nonMMF_i * stable_j$			0.0251	0.0319		
			(0.0561)	(0.0635)		
$nonMMF_i * stable_j * post_t$			0.2174	0.1883		
			(0.1691)	(0.1678)		
$nonMMF_i * stable_j * post_t * newReln_{ij}$			-0.6272**	-0.5752**		
			(0.2624)	(0.2567)		
$nonMMF_i * big_j$					0.2598***	0.2563***
					(0.0802)	(0.0935)
$nonMMF_i * big_j * post_t$					-0.2818***	-0.3141***
					(0.0896)	(0.0864)
$nonMMF_i * big_j * post_t * newReln_{ij}$					-0.0122	0.0191
					(0.0642)	(0.0596)
$highestQuote_{ab}$	0.7852***	0.7697***	0.7843***	0.7690***	0.7833***	0.7693***
	(0.0243)	(0.0268)	(0.0242)	(0.0268)	(0.0241)	(0.0269)
N	5,884	5,882	5,884	5,882	5,884	5,882
R^2	0.6878	0.6954	0.6891	0.6965	0.6897	0.6971
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE		✓		✓		✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a (only dollar auctions) with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is an non-MMF bank and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $highestQuote_{ab}$ is a dummy euqal to 1 if bid b was the highest in auction a. $stable_j$ is equal to 1 if firm j offering the deposit is a stable funding provider. big_j is equal to 1 if the average transaction size of firm j is larger or equal to the median of average transaction sizes of all other firms. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

We present results in Table VII. In line with Friedmann, Imbierowicz, Saunders and Steffen (2017), we find that the highest quote is consistently an important driver of the likelihood of winning a deposit auction, across both bank groups and periods. Moreover, we find that non-MMF banks manage to win on average more auctions from new relationship firms in the post-reform period, as column (1) and column (2) document. This higher probability of winning new relationships for non-MMF banks, however, is driven by non-stable funding providers (columns (3) and (4)). In addition, there is evidence that these banks win less often auctions with large funding providers in the post-reform period for both old and new relationship firms (columns (5) and (6)).

Overall, Table VII documents a composition effect and explains the higher deposit spread

that non-MMF banks pay after the reform. Once MMF banks lost MMF funding and intensified competition for corporate deposits, they crowded-out non-MMF banks by securing funding from firms that are most alike MMFs, i.e., stable and large deposit providing firms. In order to keep their funding volume, non-MMF banks had to form new relationships with less stable funding providers and smaller firms, and had to pay a premium for both building up new relations and keeping in place existing ones.[17]

C. Placebo test: Dollar versus pound transactions

We again rule out that non-MMF banks had a general decrease in their bidding success that is not related to the MMF reform. As before, we do this by comparing the results of dollar auctions with pound denominated auctions as a suitable control currency. Our main variables of interest in Equation 4 are again additionally interacted with a dollar dummy variable to measure the differential effect of the US MMF reform on dollar denominated transactions relative to pound denominated transactions. If the effect that we identify in Table VII originates from the US MMF reform, we should observe a significantly different effect between dollar denominated and pound denominated transactions. We estimate the following auction quote level difference-in-differences-in-differences equation:

$$\begin{aligned} WinningBid_{ijabct} = {} & \alpha_{ct} + \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot post_t \\ & + \beta_3 \cdot nonMMF_i \cdot Dollar_a + \beta_4 \cdot nonMMF_i \cdot post_t \cdot Dollar_a \\ & + \beta_5 \cdot newReln_{ij} + \beta_6 \cdot newReln_{ij} \cdot nonMMF_i \\ & + \beta_7 \cdot newReln_{ij} \cdot Dollar_a + \beta_8 \cdot newReln_{ij} \cdot nonMMF_i \cdot Dollar_a \\ & + \beta_9 \cdot stable_j(big_j) + \beta_{10} \cdot stable_j(big_j) \cdot nonMMF_i \\ & + \beta_{11} \cdot stable_j(big_j) \cdot Dollar_a + \beta_{12} \cdot stable_j(big_j) \cdot nonMMF_i \cdot Dollar_a \\ & + \beta_{13} \cdot highestQuote_{ab} + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ijabt} \end{aligned} \tag{5}$$

The dependent and control variables remain the same as in Equation 4. $Dollar_a$ is again a dummy variable that discriminates dollar transactions from pound transactions. The results are shown in Table VIII and document that non-MMF banks had a higher (lower) probability of winning auctions with new relationships (stable and big funding providers) only for dollar-denominated auctions. This result points to an increased competition after the MMF reform for dollar funding only.

[17] The results are again robust against varying the period lengths and moving pre- and post-reform periods away from April and October, respectively, for reasonably large distances, and are confirmed by period placebo tests. See Online Appendix OA and Online Appendix OB for details.

Table VIII

Bank-firm relationships and the probability of winning USD versus GBP deposit auctions

	(1)	(2)	(3)	(4)	(5)	(6)
$nonMMF_i * post_t$	0.0030	-0.0044	0.0245	0.0230	-0.1082	-0.0947
	(0.0357)	(0.0365)	(0.1008)	(0.1115)	(0.0713)	(0.0751)
$nonMMF_i * post_t * Dollar_a$	-0.0582	-0.0547	-0.2863	-0.2259	0.2729**	0.2758**
	(0.0462)	(0.0452)	(0.1733)	(0.1653)	(0.1178)	(0.1244)
$nonMMF_i * post_t * newReln_{ij}$	-0.0611	-0.0300	-0.0351	0.0090	-0.0644	-0.0340
	(0.0696)	(0.0606)	(0.1522)	(0.1611)	(0.0691)	(0.0597)
$nonMMF_i * post_t * newReln_{ij} * Dollar_a$	0.2084***	0.1936***	0.7679***	0.6849**	0.2203***	0.1886**
	(0.0684)	(0.0658)	(0.2571)	(0.2671)	(0.0821)	(0.0750)
$nonMMF_i * stable_j * post_t$			-0.0312	-0.0282		
			(0.1138)	(0.1246)		
$nonMMF_i * stable_j * post_t * Dollar_a$			0.2430	0.1711		
			(0.1706)	(0.1637)		
$nonMMF_i * stable_j * post_t * newReln_{ij}$			-0.0507	-0.0855		
			(0.1583)	(0.1808)		
$nonMMF_i * stable_j * post_t * newReln_{ij} * Dollar_a$			-0.5654**	-0.4834*		
			(0.2659)	(0.2774)		
$nonMMF_i * big_j * post_t$					0.1261	0.0986
					(0.0778)	(0.0838)
$nonMMF_i * big_j * post_t * Dollar_a$					-0.3713***	-0.3713***
					(0.1236)	(0.1265)
$nonMMF_i * big_j * post_t * newReln_{ij} * Dollar_a$					-0.0079	0.0100
					(0.0605)	(0.0586)
$highestQuote_{ab}$	0.7835***	0.7725***	0.7827***	0.7721***	0.7829***	0.7726***
	(0.0192)	(0.0207)	(0.0193)	(0.0207)	(0.0191)	(0.0207)
N	10,478	10,475	10,478	10,475	10,478	10,475
R^2	0.6775	0.6851	0.6782	0.6858	0.6786	0.6861
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE		✓		✓		✓
Currency-month FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1, if a bank is a non-MMF bank and $post_t$ a dummy variable equal to 1 in the post-reform period and $Dollar_a$ a dummy variable that equals 1 for dollar denominated transactions. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Interaction terms not including $post_t$ are not included in the table for presentational purposes. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

VI. Bank lending, risk, and performance

After the US MMF reform, non-MMF banks saw their funding costs rise and their pool of funding providers deteriorated. A natural question that arises from our results on funding markets is whether and how they affect bank lending, risk, and performance.

Assuming that the outcomes in the corporate deposit platform are representative of rising costs for non-MMF banks, we ask the following questions: Do banks pass on the rising costs to borrowers? Do banks increase risk taking to keep their profit margins? Do banks cut their lending in dollars

relative to other currencies as the sourcing of dollars becomes more expensive? Or did they lose competitiveness in lending markets through lower demand for their loans as a consequence of losing competitiveness in funding markets?

We show that non-MMF banks reduced lending rates relative to MMF banks – in particular for dollar loans – yet reduced the relative share of dollar loans in their portfolio. Their stocks underperformed those of MMF banks. However, their riskiness was not statistically different from that of MMF banks, as measured by CDS spreads. These results suggest that intensified competition in funding markets led to a decrease in profitability.

A. Bank lending

We use loan-level data from the syndicated loan market to study the differences between MMF and non-MMF banks in terms of dollar loan pricing and volumes for the period of 3 and 6 months around the MMF reform. We match the funding dataset to syndicated loan data from Dealogic, ending up with 43 non-US banks, of which 27 are MMF and 16 are non-MMF. We consider loans denominated in major currencies.[18] In the 12 months around the US MMF reform, banks in our sample originated almost 12,000 loans, split into about 32,000 loan shares (i.e., bank individual shares of a syndicated loan).

A.1. Loan pricing

We study loan pricing of bank i to firm j in loan contract l at time t and estimate the following equation for dollar loans only:

$$\begin{aligned} LoanMargin_{ijlt} = \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot post_t + \beta_3 \cdot nonMMF_i \cdot post_t \\ + \gamma \cdot \boldsymbol{X}_l + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ijlt} \end{aligned} \tag{6}$$

where $LoanMargin_{ijlt}$ describes the loan spread charged above LIBOR for loan l by bank i to firm j originated on day t. The vector $\boldsymbol{X}_l$ contains loan control variables, namely the logarithm of the face value of the loan and the loan maturity at origination (in years). $Borrower \times time$ fixed effects (α_{jt}) are included in all regressions to control for loan demand by firms. Other variables (including fixed effects and bank controls) follow the naming convention in the previous section.

Table IX presents the results for this analysis. In column (1), we estimate the baseline version of Equation 6, which includes $borrower \times time$ fixed effects as well as bank-specific controls. Column (2) controls in addition for bank fixed effects. As loan origination via a syndicate is usually negotiated over a longer period, a three month window might be too narrow to capture the post-reform effects on bank lending volumes. We therefore rerun the regressions using a 6 month window. In all specifications, we observe a negative estimate for β_3, indicating a lower spread for dollar loans

[18] The currencies considered are: AUD, CAD, CHF, DKK, EUR, GBP, HKD, JPY, SEK and USD. Six months before and after the US MMF reform implementation, these currencies account for over 95% of originated loans by our sample banks. These currencies encompass all home currencies of the banks in our sample, plus the USD. Non-USD loans were converted into USD using daily currency exchange rates.

of non-MMF banks post-reform. In the aftermath of the MMF reform, non-MMF banks cut their dollar loan margins on average by around 2 basis points relative to MMF banks.

Table IX
non-MMF banks charge less for their dollar loans post MMF reform

	(1)	(2)	(3)	(4)
Period length	3 months	3 months	6 months	6 months
$nonMMF_i$	0.3911		0.6181*	
	(0.3687)		(0.3102)	
$nonMMF_i * post_t$	-1.7310*	-1.5049	-1.7383**	-1.6196**
	(0.9565)	(0.9288)	(0.6901)	(0.7808)
$LoanSize_l$	3.0357	3.0280	-1.4702	-1.4701
	(2.2158)	(2.2183)	(1.7325)	(1.7317)
$Maturity_l$	5.4271***	5.4276***	8.1086***	8.1060***
	(1.1108)	(1.1119)	(1.8374)	(1.8367)
N	4,191	4,189	8,318	8,318
R^2	0.9004	0.9004	0.9139	0.9139
Bank controls	✓	✓	✓	✓
Borrower-month FE	✓	✓	✓	✓
Bank FE		✓		✓

Notes: OLS regressions for Equation 6. All regressions are for dollar loans. The dependent variable $LoanMargin_{ilt}$ is defined as the loan spread charged above LIBOR for loan l by bank i originated on day t. $nonMMF_i$ is a dummy variable equal to 1 if the bank is not directly affected by the MMF reform and $post_t$ a dummy variable equal to 1 in the post MMF reform period. $LoanSize_l$ stands for the logarithm of the face value of the loan, $Maturity_l$ for the remaining time (in years) until the loan matures at the time of origination. Bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. The length of the period considered for estimation before and after US MMF reform implementation is denoted below the column numbering. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Next, we compare the pricing of dollar loans versus loans in other currencies. In Equation 7 we expand on the specification in Equation 6 by including loans in all the 10 currencies in our sample, and include a dummy to capture those loans that are made in dollars:

$$\begin{aligned} LoanMargin_{ijlct} = \alpha_{ct} + \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot Dollar_c \\ + \beta_3 \cdot nonMMF_i \cdot post_t + \beta_4 \cdot nonMMF_i \cdot post_t \cdot Dollar_c + \\ + \gamma \cdot \boldsymbol{X}_l + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ilct} \end{aligned} \tag{7}$$

$LoanMargin_{ijlct}$ describes the loan spread charged above LIBOR for loan l by bank i to firm j originated on day t in currency c. $Dollar_c$ is a dummy variable equal to 1 if the loan is denominated in dollars. The vector $\boldsymbol{X}_l$ contains the same loan control variables as Equation 6 (loan size and maturity at origination). All regressions control for $currency \times month$ fixed effects (α_{ct}, absorbing all time-varying currency-specific factor), $borrower \times month$ fixed effects (α_{jt}, controlling for loan demand) and bank-specific controls. Columns (2) and (4) control in addition for bank fixed effects, thereby absorbing all time-invariant bank-specific characteristics.

Table X

Dollar loan margins after the MMF reform (Dollar vs. other currencies)

	(1)	(2)	(3)	(4)
Period length	3 months	3 months	6 month	6 months
$nonMMF_i$	-3.7259*		-2.7950**	
	(1.8975)		(1.2573)	
$nonMMF_i * Dollar_c$	5.5541**	5.6265*	4.4798**	4.3894**
	(2.6650)	(2.8185)	(1.8678)	(1.8228)
$nonMMF_i * post_t$	4.0139**	3.8064*	3.7671*	3.6484
	(1.9293)	(2.0419)	(2.1779)	(2.4120)
$nonMMF_i * post_t * Dollar_c$	-7.2823**	-6.9484**	-6.8423**	-6.6827**
	(2.9399)	(2.9858)	(2.6732)	(2.7110)
N	5,802	5,801	11,559	11,559
R^2	0.9149	0.9149	0.9246	0.9246
Bank and loan controls	✓	✓	✓	✓
Currency-month FE	✓	✓	✓	✓
Borrower-month FE	✓	✓	✓	✓
Bank FE		✓		✓

Notes: OLS regressions for Equation 7. The dependent variable $LoanMargin_{ilct}$ is defined as the loan spread charged above interbank rate (e.g., LIBOR) for loan l by bank i originated in currency c on day t. $nonMMF_i$ is a dummy variable equal to 1 if the bank is not directly affected by the MMF reform and $post_t$ a dummy variable equal to 1 in the post-reform period. $Dollar_c$ is a dummy variable equal to 1 if the loan is denominated in USD. Loan controls include the logarithm of the face value of the loan and its maturity (remaining time in years until the loan matures, at the time of origination). Bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. The length of the period considered for estimation before and after US MMF reform implementation is denoted below the column numbering. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

The triple interaction term is negative, statistically significant regardless of the specification and economically relevant. Post reform, non-MMF banks cut their loan margins on average by around 7 basis points relative to MMF banks for dollar loans. There is no such effect for loans in other currencies; in fact the effect for non-dollar loans is positive, though around half the size of the effect for dollar loans and not as strong in terms of statistical significance. This suggests that non-MMF banks could partly compensate for the profitability reduction in dollar loans by shifting their focus to other currencies, e.g., their home country currency.

A.2. Loan volumes

To study loan volumes we aggregate the loan-level data at the bank-currency-time level (i.e. loans granted by bank i in currency c at time t) and estimate the following equation:

$$\begin{aligned} LoanChange_{ict} = \alpha_{ct} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot Dollar_c \\ + \beta_3 \cdot nonMMF_i \cdot post_t + \beta_4 \cdot nonMMF_i \cdot post_t \cdot Dollar_c \\ + \delta \cdot \boldsymbol{Y}_{i(t-1year)} + \epsilon_{ict} \end{aligned} \tag{8}$$

where the dependent variable is defined either as bank i's aggregate amount of loan holdings in month t relative to month $t-1$ in currency c, i.e., dollar or non-dollar, or as the count of loans in period t relative to $t-1$ in currency c. We run this regression for both volume and number of loans as dependent variables. In the most saturated specification, we include $currency \times month$ fixed effects and bank fixed effects. The rest of the notation follows previous equations.

Table XI presents the results. The triple interaction term is negative and statistically significant, suggesting that non-MMF banks reduce the share of dollars in their lending portfolio after the reform relative to MMF banks, both in terms of volume and number of loans. The fact that non-MMF banks simultaneously charge lower loan prices for dollar loans and reduce dollar lending relative to MMF banks suggests that this might be due to a demand effect instead of these banks cutting the supply of dollar loans. As the funding costs are higher for non-MMF banks, firms might view these banks uncompetitive lenders. The positive estimate for β_3 supports the idea from the previous subsection that banks partly compensate by resorting to loans in other currencies (which are also more profitable, as shown in Table X).

Table XI
Loan holdings after the reform - USD versus other currencies

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent variable	$ChangeLoanHoldVol_{it}$				$ChangeLoanHoldCount_{it}$			
Period length	3 months	3 months	6 months	6 months	3 months	3 months	6 months	6 months
$nonMMF_i$	-0.0125**		-0.0134*		-0.0104**		-0.0087**	
	(0.0057)		(0.0067)		(0.0051)		(0.0037)	
$nonMMF_i * Dollar_c$	-0.0042	-0.0042	0.0135	0.0135	-0.0034	-0.0034	0.0044	0.0044
	(0.0093)	(0.0092)	(0.0095)	(0.0095)	(0.0068)	(0.0068)	(0.0039)	(0.0039)
$nonMMF_i * post_t$	0.0269**	0.0269**	0.0227	0.0228	0.0264	0.0264	0.0146	0.0150
	(0.0131)	(0.0130)	(0.0140)	(0.0138)	(0.0163)	(0.0162)	(0.0105)	(0.0104)
$nonMMF_i * post_t * Dollar_c$	-0.0215*	-0.0215*	-0.0382**	-0.0382**	-0.0317*	-0.0317*	-0.0238*	-0.0238*
	(0.0125)	(0.0125)	(0.0179)	(0.0179)	(0.0184)	(0.0183)	(0.0141)	(0.0141)
N	492	492	984	984	492	492	984	984
R^2	0.0537	0.0849	0.0971	0.1210	0.0425	0.0686	0.0558	0.0810
Bank controls	✓	✓	✓	✓	✓	✓	✓	✓
Currency-month FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE		✓		✓		✓		✓

Notes: OLS regressions for Equation 8. The dependent variable is defined either as bank i's aggregate amount of loan holdings in month t relative to month $t-1$ in currency c, i.e. dollar or non-dollar, ($ChangeLoanHoldVol_{ict}$ in columns (1) to (4)), or as its loan count in t relative to $t-1$ in currency c ($ChangeLoanHoldCount_{ict}$ in columns (5) to (8)). $nonMMF_i$ is a dummy variable equal to 1 if a bank is a non-MMF bankand $post_t$ a dummy variable equal to 1 in the post MMF reform period. $Dollar_c$ is a dummy variable equal to 1 if the observation contains the dollar share of loans. Bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. The length of the period considered for estimation before and after US MMF reform implementation is denoted below the column numbering. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

B. Bank performance: Default risk and stock prices

To recap our results so far: When MMF banks intensify competition for corporate deposits, this caused negative externalities on non-MMF banks. The cost of dollar funding rose and the pool

of funding providers deteriorated for non-MMF banks. Their dollar lending business also became less profitable, with declining volumes and margins relative to MMF banks.

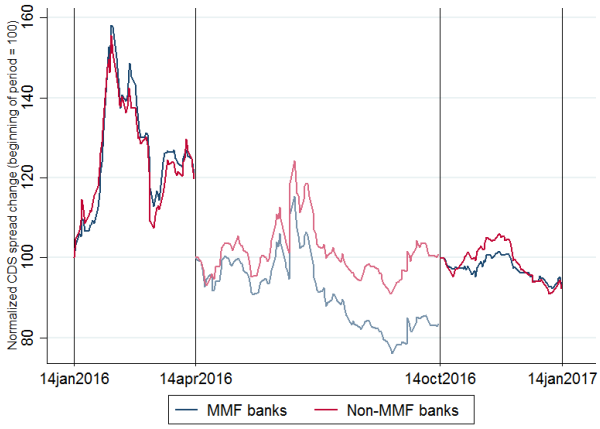
What do these results imply for bank performance? There are two potential channels affecting bank risk and performance: On the one hand, market participants might expect non-MMF banks to be less profitable. These banks may not take on profitable dollar lending opportunities or keep high profit margins, since the availability and cost of dollar funding are lower and higher, respectively. Therefore, the stocks of non-MMF banks would underperform relative to those of MMF banks. Moreover, investors would price that non-MMF banks would be vulnerable to dollar funding squeezes due to reduced availability of dollars, also increasing bank riskiness. On the other hand, investors could only price in the lower cash flows due to lower dollar profitability, but since banks also reduce lending and can (partly) compensate for the dollar stress by resorting to other currencies, they would not have a material increase in their default risk. In the data, we find evidence for the second channel.

Figure 8 presents CDS spreads and stock price performance for the two groups of banks. Graphically, there seems to be no materially different development between the CDS spreads and stock returns of the two groups of banks before the reform. After the reform, the stock prices of non-MMF banks underperform relative to those of MMF banks, whereas CDS spreads remain on a roughly similar trend. Note, however, that there is some divergence during the implementation period, around the Brexit referendum. This might potentially have confounding effects.

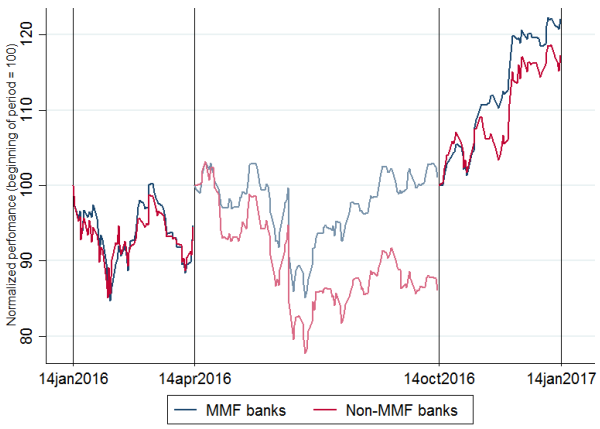
Figure 8

Bank default risk and stock prices around the MMF reform

(a) Average CDS spread change



(b) Average stock price performance



Notes: Daily CDS spread changes and stock price performance are normalized to the beginning of each sub-period (=100). US banks excluded. *Source:* S&P Global Market Intelligence, authors' calculation.

In what follows, we investigate the changes in bank performance more formally and rule out potentially confounding factors by estimating the following difference-in-differences regressions for CDS spreads and stock prices, also adding several relevant control variables:

$$Performance_{ikt} = \alpha_{kt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot post_t + \gamma \cdot Brexit + \delta \cdot \mathbf{Y}_{i(t-1year)} + \epsilon_{it} \quad (9)$$

The dependent variable $Performance_{ikt}$ is either: (i) the cumulative CDS spread change of bank i domiciled in country k in period t ($CumCDSspreadChange_{ikt}$, with t being the pre- or post-reform periods); or (ii) the three-month cumulative stock return of bank i domiciled in country k in period t ($CumStockReturn_{ikt}$) for all publicly listed banks on the deposit platform. We control for effects associated with the Brexit referendum of June 23, 2016 by including a *Brexit* dummy. For the CDS spread regressions, this dummy is defined as the CDS spread jump in percentage points two trading days after the referendum (i.e., the increase until close of business on Monday, June 27, 2016) for observations in the post-reform period and equal to 0 for observations in the pre-reform period. For the stock price regressions the dummy is in turn defined as the stock price drop in percentage points two trading days after the referendum (i.e., the drop until close of business on Monday, June 27, 2016) for observations in the post-reform period and equal to 0 for observations in the pre-reform period. The dummy variables $nonMMF_i$ and $post_t$ are defined as in previous regression specifications. In order to account for the overall development of CDS markets and stock prices as well as differences across countries over time, we add $country \times time$ fixed effects. The main variable of interest is again $nonMMF_i \times post_t$.

Table XII
CDS spreads and stock returns following the MMF reform

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	$CumCDSspreadChange_{ikt}$			$CumStockReturn_{ikt}$		
$nonMMF_i$	-2.1068	-1.3863		-0.9250	-4.2521	
	(15.3716)	(15.6785)		(7.0965)	(7.3167)	
$nonMMF_i * post_t$	7.3414	7.3979	8.5097	-15.0196**	-14.2769*	-12.4229**
	(15.7630)	(14.9332)	(15.3530)	(7.1426)	(7.1631)	(4.4685)
$Brexit$	-0.3855**	-0.3649*	-0.9933	0.9596***	1.0771***	1.5915***
	(0.1745)	(0.1939)	(0.6526)	(0.1701)	(0.1967)	(0.2049)
N	74	74	74	70	70	70
R^2	0.7446	0.7585	0.8859	0.9148	0.9209	0.9641
Bank controls	✓	✓	✓	✓	✓	✓
Country-period FE	✓	✓	✓	✓	✓	✓
Bank FE			✓			✓

Notes: OLS regressions for Equation 9. The dependent variable in columns (1)-(3) is $CumCDSspreadChange_{ikt}$ defined as cumulative CDS spread change of bank i from country k in the pre-reform or post-reform periods. In columns (4)-(6) it is $CumStockReturn_{ikt}$, defined as the three month cumulative stock return of bank i from country k in the pre-reform or post-reform periods. $nonMMF_i$ is a dummy variable equal to 1 if the bank is not directly affected by the MMF reform and $post_t$ a dummy variable equal to 1 in the post-reform period. In columns (1)-(3) *Brexit* is defined as the CDS spread change in percentage points two trading days after the referendum and is equal to 0 for observations in pre-reform period. In columns (4)-(6) *Brexit* is defined as the stock price drop in percentage points two trading days after the referendum and is equal to 0 for observations in pre-period. Bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Robust standard errors are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

In line with the second hypothesis, bank default risk does not seem to differ between the two groups of banks following the MMF reform. The regression results in columns (1)-(3) of Table XII show a positive, but statistically insignificant point estimate for the diff-in-diff coefficient, i.e., higher CDS spreads for non-MMF banks post-reform.[19] The results are not driven by the CDS spread spike after Brexit referendum and a following rebound to prior levels. The Brexit referendum seems to impact both bank groups similarly and the temporary divergence of CDS spreads in the implementation period starts already before the referendum.

As conjectured due to lower expected profitability, non-MMF banks' stocks underperform. Columns (4)-(6) in Table XII show a statistically significant and economically large effect (larger than suggested by the right-hand panel of Figure 8): MMF banks exhibit 12-15 additional percentage points stock price growth after controlling for *country* × *time* fixed effects, *bank* specific factors, and a potential Brexit recovery impact. The results are not driven by the stock price drop after Brexit referendum and a following rebound to prior levels. In fact, the divergence of stock prices starts with the implementation of the US MMF reform and the Brexit referendum seems to impact both bank groups similarly.[20] Moreover, the stock performance seems to confirm that the results from the deposit trading platform and the syndicated loan market are representative for a general detrimental effect of the US MMF reform on non-MMF banks. This negative effect seems to operate first through negative spillovers in short-term wholesale dollar funding markets and is aggrevated by the loss of competitiveness in lending markets.[21]

VII. Conclusion

We contribute to the literature on funding market dry-ups by identifying a new channel of spillovers in which a funding dry-up in one market propagates to other markets through intensified competition. Moreover, we show that these spillovers are material in that they affect bank lending and stock market performance. We also contribute to the literature on bank competition in funding markets by showing that banks' competitiveness in funding markets affects their competitiveness in lending markets.

We exploit a policy reform that led to a wholesale funding dry-up in one market during an otherwise tranquil period for funding markets to study the dynamics of funding dry-ups without the confounding factors usually present during a crisis. When the US MMF reform reduced the availability of unsecured funding for some banks, they tapped into the corporate deposit markets

[19] We obtain similar results if we focus on narrower windows, such as one month. Results are available upon request.

[20] Taking UK banks and the 5-10% banks that were hit most severely by the Brexit referendum turbulences out of the analysis does not change the results for either CDS spreads or stock prices. These and other robustness checks related to the impact of the Brexit referendum can be found in the Online Appendix OC and the Online Appendix OD.

[21] As the deposit trading platform is only one of several avenues available for banks' funding substitution, the observed magnitude of stock price results needs to be driven by a larger effect of wholesale funding substitution on banks' competitiveness. In this sense, we view the corporate deposit platform as a microcosm of broader market developments, which are inter alia also reflected in the syndicated loan market.

intensifying competition with other banks. As a result, the initially unaffected banks had to pay higher deposit rates relative to MMF banks to retain funding, and were crowded out from stable funding providers. They lent less and at lower prices relative to MMF banks. Furthermore, their profit margins declined and stocks underperformed. Nevertheless, there was no material change in their riskiness.

Another contribution of our paper is to provide new insights into corporate deposit markets using a unique and granular dataset. Despite their increasing importance and potential to lead to financial instability, data unavailability has previously hindered the study of these markets. However, even though our dataset provides rich information, it only covers a small segment of the market for corporate deposits. Further studies using other segments of corporate deposit markets would be useful to understand these markets and how they might affect financial stability.

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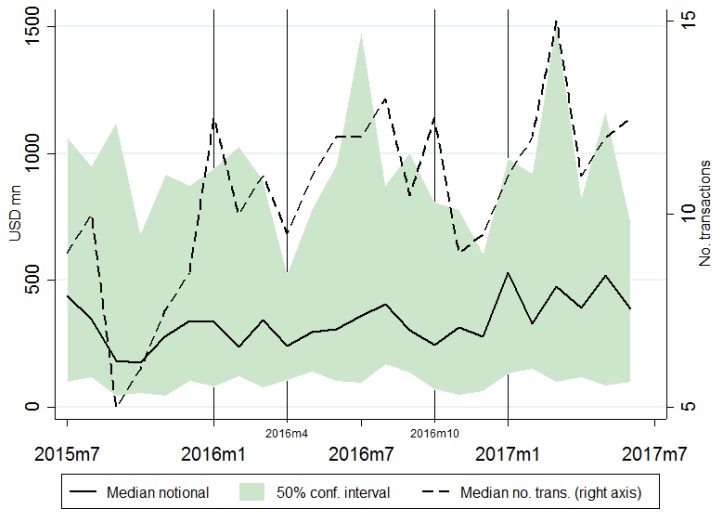
Appendix

Appendix A Additional summary statistics

Figure A.1
Monthly notional deposit amount and number of transactions per bank



Notes: The solid line depicts the median and the green area describes the first and third quartile of monthly notional deposit amounts executed by bank. The dashed line denotes the median number of transactions executed by bank to realize the monthly volumes.

Table A.1

Share of transactions by country of headquarters and bank group (%), pre and post reform

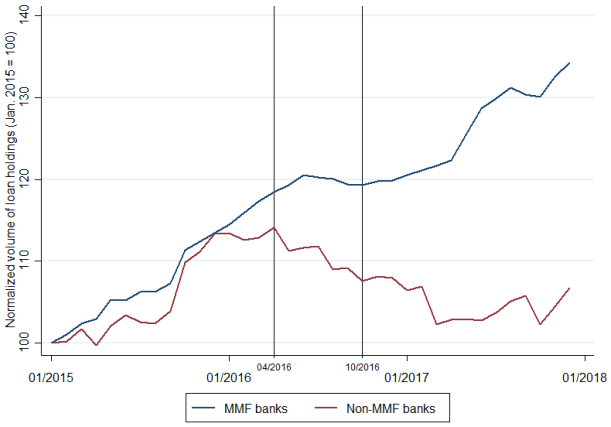
Bank group	Treated		Non-treated	
Period	Pre	Post	Pre	Post
Australia	9	7	-	-
Austria	-	-	8	18
Belgium	-	-	8	4
Canada	4	5	-	-
China	<1	<1	-	-
Denmark	1	-	-	-
France	26	25	-	-
Germany	<1	1	51	47
Hong Kong	<1	<1	-	-
Italy	-	-	12	6
Japan	17	18	-	-
Netherlands	17	19	-	-
Spain	<1	<1	2	3
Sweden	2	3	-	-
Switzerland	<1	<1	13	12
Thailand	-	-	3	9
United Kingdom	17	11	2	2
United States	5	9	-	-

Source:Corporate deposit data, authors' calculations.

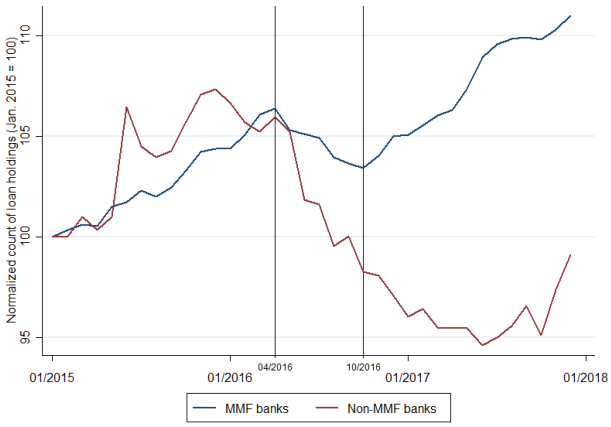
Figure A.2

Development of syndicated loan holdings – Dollar denominated loans

(a) Volume of loan holdings



(b) Count of loan holdings



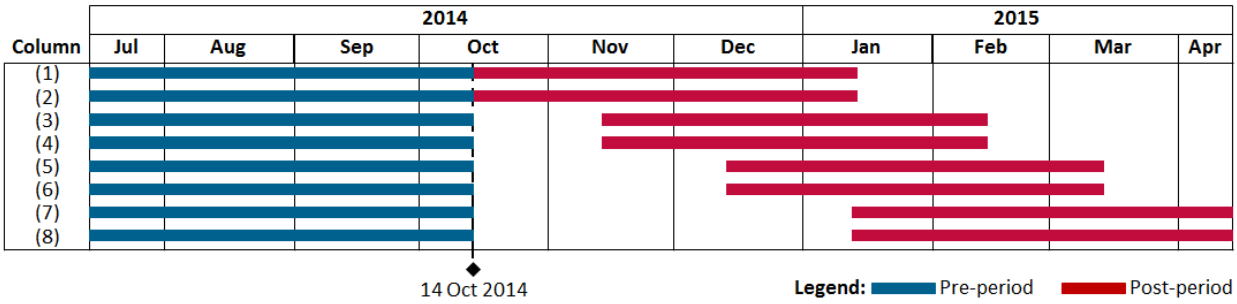
Notes: Volume and count of syndicated loan holdings are normalized to the beginning of 2015 (=100). US banks excluded.
Source: Dealogic, authors' calculation.

Appendix B Additional robustness tests

Anticipation effects. The SEC adopted several amendments to the rules that govern MMFs in US under the Investment Company Act of 1940 on July 23, 2014. The effective date of such amendments was set to October 14, 2014. Given the short nature of the market which the reform targets, large anticipation effects should not occur long before the first compliance date on April 14, 2016. However, Figure 6 hints at an anticipation shortly after the law came into effect. To formally test this anticipation for our treatment and control groups, we run the regression in Equation 2 for different period definitions as specified in Figure B.1. The pre-reform period is defined as the three months before the effective date of the law. We test four different definitions of the post-reform period accounting for potentially delayed effects of the law.

Figure B.1

Anticipation of reform implementation after October 2014 - Period definitions for regressions



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table B.1. All periods have a length of three months starting on the 13th and ending on the 14th of a month.

Table B.1 presents the results of testing for a potential effect after the adoption of the law in October 2014. For the post-reform period definitions that include the year-end of 2014, there is either no statistically significant or a small negative effect (columns (1)-(6)). The post-reform period starting mid of January 2015 indicates a small early anticipation effect, which, however, loses statistical significance after controlling for time-invariant bank-specific characteristics. Consequently, we conclude that there is no empirical evidence for an early anticipation effect and that periods around the compliance dates (i.e., the implementation of the reform) capture the reform's effect of interest.

Parallel trends. The validity of results further requires the parallel assumption to be fulfilled prior to the first compliance date on April 14, 2016. The right panel of Figure 6 in the main text already presented a visual summary of the results obtained from estimating the following equation:

Table B.1

Corporate deposit spreads - Anticipation of reform implementation after October 2014

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Period length:	3months							
Pre-period from:	14/07/2014							
to:	13/10/2014							
Post-period from:	14/10/2014		14/11/2014		14/12/2014		14/01/2015	
to:	13/01/2015		13/02/2015		13/03/2015		13/04/2015	
$nonMMF_i$	0.3137		0.5405		0.9577		1.0253	
	(1.3199)		(1.3638)		(1.2630)		(1.2255)	
$nonMMF_i * post_t$	0.8848	-0.9210**	0.5862	-1.2986*	1.9890	0.4127	2.9828*	1.3138
	(0.5565)	(0.4142)	(0.8035)	(0.7595)	(1.3080)	(0.9445)	(1.6112)	(1.1070)
$YearEnd$	-1.7638	-0.6647	-1.8449	-0.7011	0.4917	1.1638		
	(2.9958)	(2.6380)	(3.0162)	(2.5970)	(0.8025)	(0.8918)		
$YearEnd * nonMMF_i$	-0.1162	-0.3551	0.0033	-0.2769	-2.9703	-2.7569**		
	(3.3554)	(2.5782)	(3.4932)	(2.7129)	(2.3384)	(1.2133)		
$Notional_a$	0.0537	-0.2897	0.0214	-0.3333	0.4375	0.0046	0.1756	-0.0799
	(0.5987)	(0.3918)	(0.6016)	(0.4253)	(0.3249)	(0.1142)	(0.2651)	(0.0791)
$Maturity_a$	0.0149	-0.0150	0.0211	-0.0120	0.0353**	0.0233**	0.0374**	0.0292**
	(0.0157)	(0.0277)	(0.0172)	(0.0321)	(0.0148)	(0.0113)	(0.0154)	(0.0124)
$Size_{it-1}$	-0.4586	-9.9874	-0.5132	-4.3796	-0.2936	0.3142	-0.2383	-0.9313
	(0.4089)	(8.7574)	(0.4231)	(6.3784)	(0.4181)	(4.5176)	(0.4250)	(5.2286)
$Leverage_{it-1}$	0.1960	0.2064	0.1932	-0.0405	0.2754***	-0.1680	0.2554***	-0.1732
	(0.1356)	(0.3689)	(0.1387)	(0.2112)	(0.0889)	(0.1217)	(0.0884)	(0.1218)
NII_{it-1}	1.5881	6.7771	1.3535	4.4301*	-3.0414	3.0822	-3.9973	2.5707
	(6.4238)	(5.1899)	(6.2402)	(2.4308)	(3.8307)	(2.7234)	(3.8142)	(2.8793)
N	3636	3635	3584	3582	3508	3506	3479	3478
R^2	0.2376	0.2733	0.2284	0.2632	0.8836	0.9425	0.8770	0.9252
Firm-month FE	✓	✓	✓	✓	✓	✓	✓	✓
Bank FE		✓		✓		✓		✓

Notes: OLS regressions for Equation 2. The dependent variable is the deposit spread $Spread_{ijat}$ defined as the deposit interest rate minus USD LIBOR rate of comparable maturity (in basis points), payed by bank i to firm j in auction a at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is not directly affected by the reform and $post_t$ a dummy variable equal to 1 in the post MMF reform period. $Notional_a$ stands for the logarithm of the notional deposit amount, $Maturity_a$ for the remaining time (in days) until the funding matures, $Size_{it}$ stands for the logarithm of bank total assets, $Leverage_{it}$ for total assets over equity, NII_{it} for the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure B.1 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

$$
\begin{aligned}
Spread_{ijat} = {} & \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i \\
& + \beta_2 \cdot nonMMF_i \cdot pre(6m)_t + \cdots + \beta_6 \cdot nonMMF_i \cdot pre(2m)_t \\
& + \beta_7 \cdot nonMMF_i \cdot post(1m)_t + \cdots + \beta_1 2 \cdot nonMMF_i \cdot post(6m)_t \\
& + \beta_1 3 \cdot YearEnd_t + \beta_1 4 \cdot YearEnd_t \cdot MMF_i + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1)} + \epsilon_{ijat}
\end{aligned} \tag{10}
$$

The post-reform variable is split into monthly indicators starting six months prior to April 14, 2016 until six months after October 14, 2016. The month directly before the first compliance date is left out as reference point for the analysis. The parallel trend is confirmed if all pre-reform period interactions do not exhibit a significant divergence from zero – and especially no positive one – while the post-reform period interactions diverge from zero, in our case in the positive direction. Results in Table B.2 confirm the parallel trend assumption with no or slightly negative divergence

from zero before the first compliance date.

Table B.2
Regression on deposit spread - Parallel trend test

	(1)	(2)	(3)	(4)	(5)	(6)
$nonMMF_i$	2.7587*					
	(1.4982)					
pre(6m) * $nonMMF_i$	-2.4666**	0.4769	0.4067	0.3345	0.6195	0.4976
	(1.0155)	(0.9589)	(0.9609)	(0.9372)	(0.9879)	(0.9254)
pre(5m) * $nonMMF_i$	-1.2195	-0.0717	-0.1841	-0.2748	0.1345	-0.4658
	(1.2309)	(1.0885)	(1.0196)	(0.9766)	(1.0585)	(0.9736)
pre(4m) * $nonMMF_i$	-2.8340*	-3.0692**	-2.9740*	-3.0043*	-2.8737*	-2.1760*
	(1.5881)	(1.5102)	(1.5177)	(1.5172)	(1.5325)	(1.2932)
pre(3m) * $nonMMF_i$	-0.2797	-0.9915	-0.9082	-0.9473	-0.8884	-1.1488
	(0.9254)	(0.7846)	(0.7810)	(0.7720)	(0.7867)	(0.8383)
pre(2m) * $nonMMF_i$	-0.5147	-1.4276**	-1.2784**	-1.3108**	-1.2702**	-1.1891**
	(0.8896)	(0.6416)	(0.6019)	(0.6070)	(0.6076)	(0.5685)
pre(1m) * $nonMMF_i$				*omitted*		
post(1m) * $nonMMF_i$	2.1673	2.5028	2.6981	2.7120	2.6922	2.9906**
	(2.8666)	(1.6492)	(1.6773)	(1.6743)	(1.6317)	(1.4390)
post(2m) * $nonMMF_i$	2.9927	3.9230**	4.0913**	4.1435**	4.0764**	4.5115***
	(1.9817)	(1.7883)	(1.7319)	(1.7249)	(1.6898)	(1.5185)
post(3m) * $nonMMF_i$	11.6033**	10.8567**	10.9764**	11.0177**	10.7471**	10.7090**
	(4.4278)	(4.4785)	(4.3329)	(4.3538)	(4.3087)	(4.5418)
post(4m) * $nonMMF_i$	1.1789	3.3362**	3.2717**	3.2916**	3.0191*	2.1257
	(1.5467)	(1.6268)	(1.6179)	(1.6249)	(1.6410)	(1.5797)
post(5m) * $nonMMF_i$	-0.7206	1.4983	1.7217	1.7858	1.4547	1.3813
	(1.5687)	(1.3346)	(1.3037)	(1.3073)	(1.3347)	(1.2718)
post(6m) * $nonMMF_i$	-0.8760	1.2303	1.3198	1.3770	1.1507	1.2053
	(1.2297)	(1.1345)	(1.1290)	(1.1427)	(1.1096)	(1.1298)
N	8185	8181	8181	8181	8181	6894
R^2	0.4525	0.5191	0.5299	0.5299	0.5303	0.6216
Bank and auction controls	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓
Bank FE		✓	✓	✓	✓	✓

Notes: The dependent variable is the deposit spread $Spread_{ijat}$ defined as the deposit interest rate minus USD LIBOR rate of comparable maturity (in basis points), payed by bank i to firm j in auction a at time t. $nonMMF_i$ is a dummy variable equal to 1 if the bank is not directly affected by the MMF reform and $post_t$ a dummy variable equal to 1 in the post MMF reform period. Auction controls include $Notional_a$ (logarithm of the notional deposit amount) and $Maturity_a$ (remaining time – in days – until the funding matures). Bank controls include $Size_{it}$ (logarithm of bank total assets), $Leverage_{it}$ (total assets over equity), and NII_{it} (share of net interest income of bank's total revenue). The regression also controls for year end effects by an $YearEnd$ dummy (not shown for presentation purposes). The different pre- and post-reform period dummy variables describe one month each. The number in parentheses counts the months starting in April 13 or October 2016, respectively. Thus pre(2m) describes the period form February 14, 2016 to March 13, 2016. The first month directly before the implementation period (i.e., pre(1m)) has been omitted as reference point. In column (6), we use only a reduced sample of firms that interact at least once with banks from either group of MMF banks and non-MMF banks. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Bank heterogeneity. In order to show that our key result on corporate deposit spreads is not driven by bank heteregeneity, we estimate the following equation:

$$
\begin{aligned}
Spread_{ijat} = \alpha_{jt} + (\alpha_i +)\beta_1 \cdot nonMMF_i + \beta_2 \cdot nonMMF_i \cdot BIG_i|LEV_i||NII_i \\
+ \beta_3 \cdot nonMMF_i \cdot post_t + \beta_4 \cdot nonMMF_i \cdot BIG_i|LEV_i|NII_i \cdot post_t \\
+ \beta_5 YearEnd_t + \beta_6 YearEnd_t \cdot nonMMF_i + \gamma \cdot \boldsymbol{X}_a + \delta \cdot \boldsymbol{Y}_{i(t-1)} + \epsilon_{ijat}
\end{aligned} \tag{11}
$$

where $BIG_i|LEV_i|NII_i$ represent different bank characteristics and equal to 1 if the respective indicator for bank i is above the median (size, leverage, and net interest income share, respectively). Each of these characteristics is interacted with the dummy capturing whether a bank is not directly affected by the MMF reform. All other variables are as in previous regressions. As the results in Table B.3 show, bank heterogeneity in terms of some key bank-specific characteristics is not significant in explaining our results. None of the triple interactions involving these bank characteristics is significant, whereas our difference-in-differences coefficient β_3 remains statistically and economically significant.

Table B.3
Corporate deposit spreads after the MMF reform – The role of bank heterogeneity

Indicator level	(1) global	(2) global	(3) global	(4) group	(5) group	(6) group
$nonMMF_i * post_t$	8.1198**	7.4817***	6.9215**	11.7044***	7.7195***	6.9215**
	(3.2432)	(2.0056)	(2.8480)	(4.0675)	(2.2329)	(2.8480)
$nonMMF_i * BIG_i * post_t$	2.0686			-4.1216		
	(3.2801)			(4.1561)		
$nonMMF_i * LEV_i * post_t$		3.3373			2.1604	
		(5.2787)			(4.5947)	
$nonMMF_i * NII_i * post_t$			4.0096			4.0096
			(5.5407)			(5.5407)
N	3872	3872	3872	3872	3872	3872
R^2	0.5326	0.5327	0.5327	0.5327	0.5326	0.5327
Bank and auction controls	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 11. The dependent variable is the deposit spread $Spread_{ijat}$ defined as the deposit interest rate minus USD LIBOR rate of comparable maturity (in basis points), payed by bank i to firm j in auction a at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post MMF reform period. The bank indicators BIG, LEV, NII are equal to 1 for banks with an above median value for log(total assets), Leverage, NII share of total revenues, respectively. In columns (1) to (3) bank indicators are defined over the entire sample of banks ("global level"); in columns (4) to (6) within the groups of treated and non-treated banks ("group level"). Auction controls include $Notional_a$ (logarithm of the notional deposit amount) and $Maturity_a$ (remaining time – in days – until the funding matures). Bank controls include $Size_{it}$ (logarithm of bank total assets), $Leverage_{it}$ (total assets over equity), and NII_{it} (share of net interest income of bank's total revenue). The regression also controls for year end effects by an $YearEnd$ dummy (not shown for presentation purposes). In column (6), we use only a reduced sample of firms that interact at least once with banks from either group of MMF banks and non-MMF banks. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Online Appendix

[FOR ONLINE PUBLICATION ONLY]

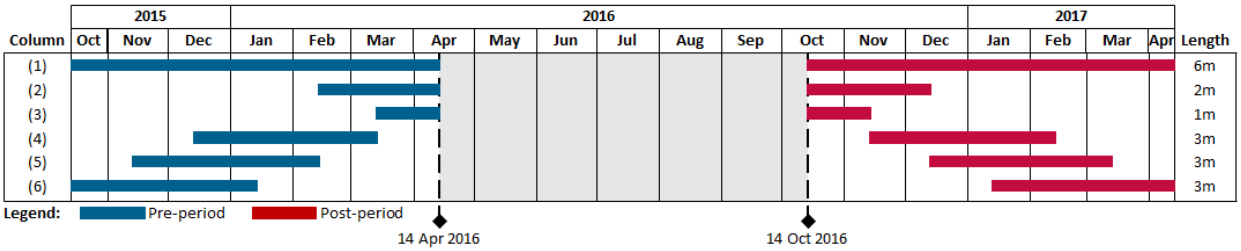
In this appendix, we provide the tables for the robustness checks discussed in the main text and the appendix of the paper. Below we list all robustness checks and the corresponding figures/tables:

- **Figure OA1**: Corporate deposit spreads - Variation of pre- and post-reform periods - Period definitions
- **Table OA1**: Corporate deposit spreads - Variation of pre- and post-reform periods
- **Figure OA2**: Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (I/III)
- **Figure OA3**: Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (II/III)
- **Figure OA4**: Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (III/III)
- **Table OA2**: Regression on winning bid - Variation of pre-reform and post-reform periods (I/III)
- **Table OA3**: Regression on winning bid - Variation of pre-reform and post-reform periods (II/III)
- **Table OA4**: Regression on winning bid - Variation of pre-reform and post-reform periods (III/III)
- **Figure OB1**: Corporate deposit spread - Placebo tests - Period definitions
- **Table OB1**: Corporate deposit spread - Placebo tests
- **Figure OB2**: Winning bid - Placebo tests pre-reform period - Period definitions
- **Figure OB3**: Winning bid - Placebo tests post-reform period - Period definitions
- **Table OB2**: Winning bid - Placebo tests pre-reform period
- **Table OB3**: Winning bid - Placebo tests post-reform period
- **Figure OC1**: Average CDS spread change
  Excluding top 10% of banks most severely hit by Brexit (7 banks) & excluding UK banks
- **Table OC1**: Regression on CDS spread changes
  Excluding top 10% of banks most severely hit by Brexit (7 banks) & excluding UK banks
- **Figure OD1**: Average stock price performance
  Excluding top 10% of banks most severely hit by Brexit (5 banks) & excluding UK banks
- **Table OD1**: Regression on stock price performance
  Excluding top 10% of banks most severely hit by Brexit (5 banks) & excluding UK banks

Online Appendix OA Alternative pre- and post-reform periods

Figure OA1

Corporate deposit spreads - Variation of pre- and post-reform periods - Period definitions



Notes: Definition of pre- and post-reform periods around the implementation of the US MMF reform corresponding to the regressions in Table OA1. Period lengths as indicated in the right-hand side column starting on the 13th and ending on the 14th of a month.

Table OA1

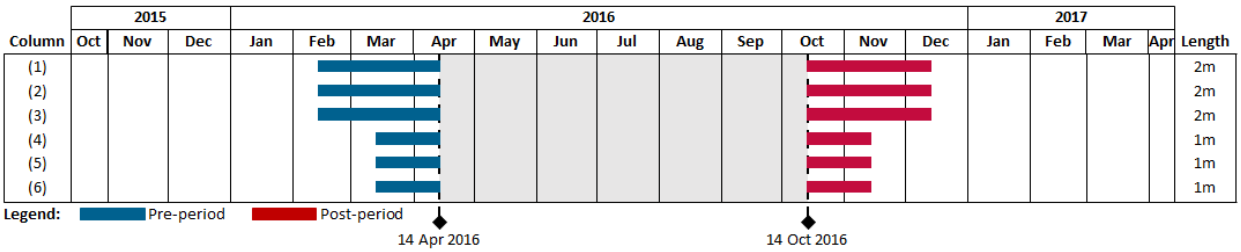
Corporate deposit spreads - Variation of pre- and post-reform periods

	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	6 months	2 months	1 month	3months	3 months	3 months
Pre-period from:	14/10/2015	14/02/2016	14/03/2016	14/12/2015	14/11/2015	14/10/2015
to:	13/04/2016	13/04/2016	13/04/2016	13/03/2016	13/02/2016	13/01/2016
Post-period from:	14/10/2016	14/10/2016	14/10/2016	14/11/2016	14/12/2016	14/01/2017
to:	13/04/2017	13/12/2016	13/11/2016	13/01/2017	13/02/2017	13/04/2017
$nonMMF_i * post_t$	4.0643***	4.0627**	3.9589**	8.2039***	4.5049***	0.8610
	(1.3099)	(1.5742)	(1.5643)	(2.7480)	(1.6601)	(0.9704)
N	8181	2544	1230	3988	3962	4280
R^2	0.5279	0.7259	0.7734	0.5039	0.5056	0.6852
Year-end, bank, and auction controls	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 2. The dependent variable is the deposit spread $Spread_{ijat}$ defined as the deposit interest rate minus USD LIBOR rate of comparable maturity (in basis points), payed by bank i to firm j in auction a at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is a non-MMF bankand $post_t$ a dummy variable equal to 1 in the post MMF reform period. Auction controls include $Notional_a$ (logarithm of the notional deposit amount) and $Maturity_a$ (remaining time in days until the funding matures). Bank controls include $Size_{it}$ (logarithm of bank total assets), $Leverage_{it}$ (total assets over equity) and NII_{it} (share of net interest income of bank's total revenue), all lagged by one year. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OA1 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Figure OA2

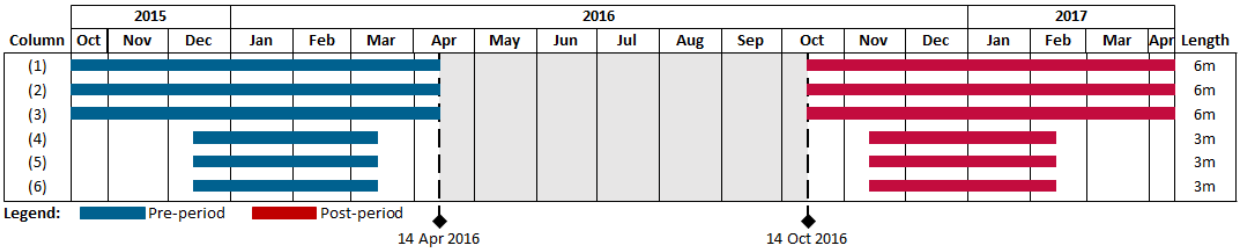
Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (I/III)



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OA2. Period lengths as indicated in the right-hand side column starting on the 13th and ending on the 14th of a month.

Figure OA3

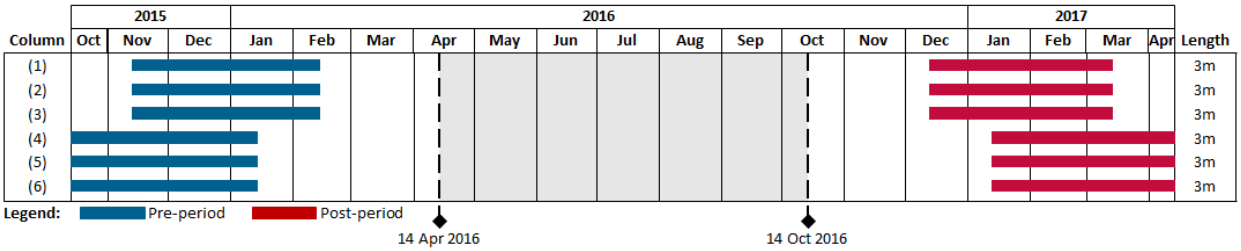
Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (II/III)



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OA3. Period lengths as indicated in the right-hand side column starting on 13th and ending on the 14th of a month.

Figure OA4

Regression on winning bid - Variation of pre-reform and post-reform periods - Period definitions (III/III)



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OA4. Period lengths as indicated in the right-hand side column starting on the 13th and ending on the 14th of a month.

Table OA2

Regression on winning bid - Variation of pre-reform and post-reform periods (I/III)

	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	2 months	2 months	2 months	1 month	1 month	1 month
Pre-period from:	14/02/2016	14/02/2016	14/02/2016	14/03/2016	14/03/2016	14/03/2016
to:	13/04/2016	13/04/2016	13/04/2016	13/04/2016	13/04/2016	13/04/2016
Post-period from:	14/10/2016	14/10/2016	14/10/2016	14/10/2016	14/10/2016	14/10/2016
to:	13/12/2016	13/12/2016	13/12/2016	13/11/2016	13/11/2016	13/11/2016
$nonMMF_i * post_t$	-0.1174**	-0.8129***	0.1187*	-0.1061**	-0.8062**	0.1480**
	(0.0515)	(0.2298)	(0.0645)	(0.0505)	(0.3949)	(0.0704)
$nonMMF_i * post_t * newReln_{ij}$	0.2332***	1.1367***	0.3377***	0.3338***	0.8139*	0.2620***
	(0.0685)	(0.2887)	(0.1160)	(0.0682)	(0.4335)	(0.0747)
$nonMMF_i * stable_j$		-0.0452			-0.1578***	
		(0.0609)			(0.0518)	
$nonMMF_i * stable_j * post_t$		0.7246***			0.7510*	
		(0.2467)			(0.4090)	
$nonMMF_i * stable_j * post_t * newReln_{ij}$		-0.9521***			-0.4891	
		(0.2849)			(0.4411)	
$nonMMF_i * big_j$			0.1923**			0.2666***
			(0.0732)			(0.0794)
$nonMMF_i * big_j * post_t$			-0.2729***			-0.2930***
			(0.0844)			(0.0813)
$nonMMF_i * big_j * post_t * newReln_{ij}$			-0.0990			0.0739
			(0.1195)			(0.0945)
$highestQuote_{ab}$	0.7665***	0.7655***	0.7658***	0.7574***	0.7574***	0.7573***
	(0.0298)	(0.0297)	(0.0299)	(0.0423)	(0.0423)	(0.0424)
N	3899	3899	3899	1989	1989	1989
R^2	0.6947	0.6978	0.6957	0.6910	0.6931	0.6922
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OA2 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Table OA3

Regression on winning bid - Variation of pre-reform and post-reform periods (II/III)

	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	6 months	6 months	6 months	3 months	3 months	3 months
Pre-period from:	14/10/2015	14/10/2015	14/10/2015	14/12/2015	14/12/2015	14/12/2015
to:	13/04/2016	13/04/2016	13/04/2016	13/03/2016	13/04/2016	13/04/2016
Post-period from:	14/10/2016	14/10/2016	14/10/2016	14/11/2016	14/10/2016	14/10/2016
to:	13/04/2017	13/04/2017	13/04/2017	13/01/2017	13/11/2016	13/11/2016
$nonMMF_i * post_t$	-0.0722*	-0.0865	0.0381	-0.0656*	0.0118	0.1568**
	(0.0380)	(0.0860)	(0.0593)	(0.0353)	(0.1043)	(0.0741)
$nonMMF_i * post_t * newReln_{ij}$	0.0776	0.3620***	-0.1185	0.0526	0.3893***	0.1032
	(0.0808)	(0.0872)	(0.2193)	(0.0471)	(0.1091)	(0.1301)
$nonMMF_i * stable_j$		0.0053			0.1231*	
		(0.0571)			(0.0710)	
$nonMMF_i * stable_j * post_t$		0.0177			-0.0927	
		(0.0858)			(0.1028)	
$nonMMF_i * stable_j * post_t * newReln_{ij}$		-0.3180***			-0.4190***	
		(0.1104)			(0.1126)	
$nonMMF_i * big_j$			0.2249***			0.2334**
			(0.0724)			(0.0937)
$nonMMF_i * big_j * post_t$			-0.1279*			-0.2570***
			(0.0697)			(0.0719)
$nonMMF_i * big_j * post_t * newReln_{ij}$			0.2270			-0.0644
			(0.2047)			(0.1180)
$highestQuote_{ab}$	0.7367***	0.7366***	0.7371***	0.7440***	0.7452***	0.7446***
	(0.0247)	(0.0248)	(0.0246)	(0.0219)	(0.0220)	(0.0218)
N	4186	4185	4186	4185	4186	4185
R^2	0.6998	0.7109	0.7005	0.7116	0.7025	0.7128
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OA3 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Table OA4

Regression on winning bid - Variation of pre-reform and post-reform periods (III/III)

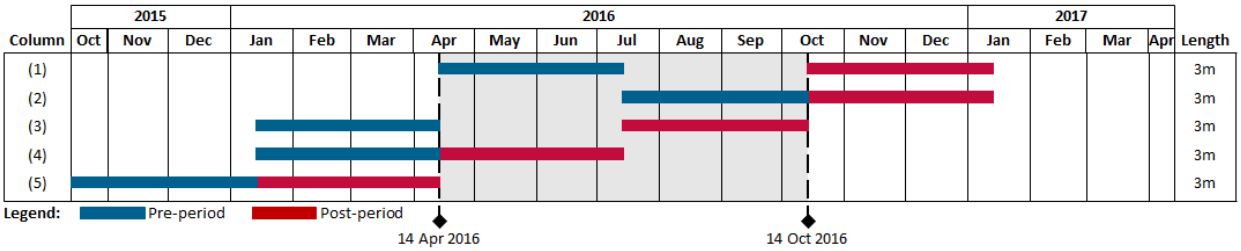
	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	3 months	3 months	3 months	3 months	3 months	3 months
Pre-period from:	14/11/2015	14/11/2015	14/11/2015	14/10/2015	14/10/2015	14/10/2015
to:	13/02/2016	13/02/2016	13/02/2016	13/01/2016	13/01/2016	13/01/2016
Post-period from:	14/12/2016	14/12/2016	14/12/2016	14/01/2017	14/01/2017	14/01/2017
to:	13/02/2017	13/02/2017	13/02/2017	13/04/2017	13/04/2017	13/04/2017
$nonMMF_i * post_t$	-0.0245	0.0096	0.1262	-0.0550	-0.0436	-0.0651
	(0.0352)	(0.0671)	(0.0812)	(0.0605)	(0.0976)	(0.0958)
$nonMMF_i * post_t * newReln_{ij}$	0.0014	0.2285**	0.0579	-0.0026	0.2449**	0.0010
	(0.0791)	(0.1011)	(0.1727)	(0.0985)	(0.1075)	(0.2129)
$nonMMF_i * stable_j$		0.0111			-0.0614	
		(0.0591)			(0.0781)	
$nonMMF_i * stable_j * post_t$		-0.0326			0.0042	
		(0.0681)			(0.1056)	
$nonMMF_i * stable_j * post_t * newReln_{ij}$		-0.2710**			-0.2825*	
		(0.1269)			(0.1460)	
$nonMMF_i * big_j$			0.2459**			0.1759*
			(0.0931)			(0.0888)
$nonMMF_i * big_j * post_t$			-0.1666*			0.0098
			(0.0840)			(0.1147)
$nonMMF_i * big_j * post_t * newReln_{ij}$			-0.0846			-0.0005
			(0.1603)			(0.1997)
$highestQuote_{ab}$	0.7395***	0.7399***	0.7405***	0.7156***	0.7162***	0.7151***
	(0.0230)	(0.0231)	(0.0229)	(0.0285)	(0.0285)	(0.0284)
N	6206	6206	6206	6882	6882	6882
R^2	0.6413	0.6417	0.6427	0.6136	0.6141	0.6146
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OA4 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Online Appendix OB Placebo tests

Figure OB1

Corporate deposit spread - Placebo tests - Period definitions



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OB1. Period lengths as indicated in the right-hand side column starting on 13th and ending on the 14th of a month.

Table OB1

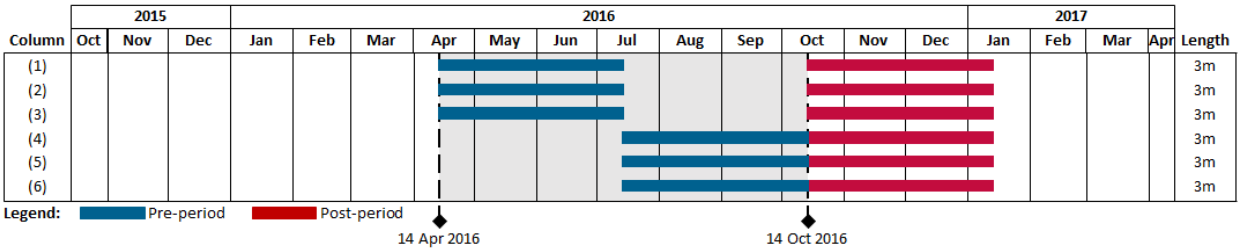
Corporate deposit spread - Placebo tests

	(1)	(2)	(3)	(4)	(5)
Period length:	3months	3months	3months	3months	3months
Pre-period from:	14/04/2016	14/07/2016	14/01/2016	14/01/2016	14/10/2015
to:	13/07/2016	13/10/2016	13/04/2016	13/04/2016	13/01/2016
Post-period from:	14/10/2016	14/10/2016	14/04/2016	14/07/2016	14/01/2016
to:	13/01/2017	13/01/2017	13/07/2016	13/10/2016	13/04/2016
$nonMMF_i * post_t$	6.6569***	3.8193**	0.0024	3.1609**	1.3433
	(2.0602)	(1.6345)	(0.5406)	(1.3817)	(0.8121)
N	4093	4394	4035	4305	3930
R^2	0.5434	0.5414	0.7721	0.6965	0.7371
Year-end, bank, and auction controls	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 2. The dependent variable is the deposit spread $Spread_{ijt}$ defined as deposit interest rate minus USD LIBOR rate of comparable maturity in basis points. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. Auction controls include $Notional_a$ (logarithm of the notional deposit amount) and $Maturity_a$ (remaining time in days until the funding matures). Bank controls include $Size_{it}$ (logarithm of bank total assets), $Leverage_{it}$ (total assets over equity) and NII_{it} (share of net interest income of bank's total revenue), all lagged by one year. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OB1 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Figure OB2

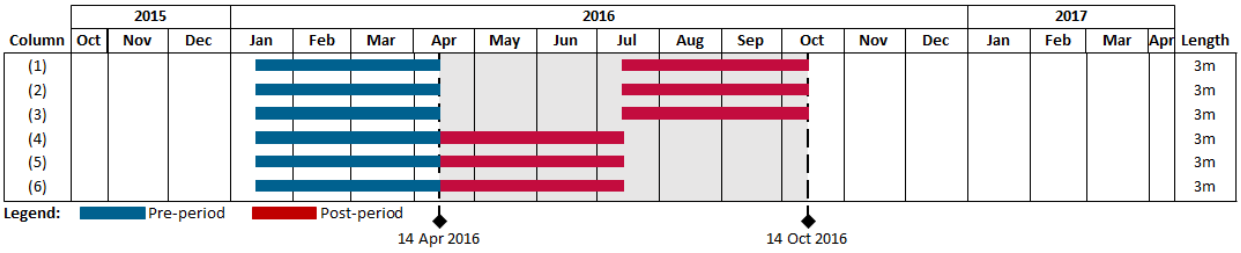
Winning bid - Placebo tests pre-reform period - Period definitions



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OB2. Period lengths as indicated in the right-hand side column starting on 13th and ending on the 14th of a month.

Figure OB3

Winning bid - Placebo tests post-reform period - Period definitions



Notes: Definition of pre- and post-reform periods around the effective date of the US MMF reform on October 14, 2014, corresponding to the regressions in Table OB3. Period lengths as indicated in the right-hand side column starting on the 13th and ending on the 14th of a month.

Table OB2

Winning bid - Placebo tests pre-reform period

	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	3 months	3 months	3 months	3 months	3 months	3 months
Pre-period from:	14/04/2016	14/04/2016	14/04/2016	14/07/2016	14/07/2016	14/07/2016
to:	13/07/2016	13/07/2016	13/07/2016	13/10/2016	13/10/2016	13/10/2016
Post-period from:	14/10/2016	14/10/2016	14/10/2016	14/10/2016	14/10/2016	14/10/2016
to:	13/01/2017	13/01/2017	13/01/2017	13/01/2017	13/01/2017	13/01/2017
$nonMMF_i * post_t$	-0.0844**	-0.3333**	0.0309	-0.0410	-0.2308	0.0559
	(0.0377)	(0.1484)	(0.0476)	(0.0280)	(0.1404)	(0.0404)
$nonMMF_i * post_t * newReln_{ij}$	0.1493***	0.6532**	0.1437***	0.1753***	0.6693**	0.1512***
	(0.0501)	(0.2464)	(0.0526)	(0.0509)	(0.2527)	(0.0557)
$nonMMF_i * stable_j$		-0.0655			-0.0334	
		(0.0437)			(0.0715)	
$nonMMF_i * stable_j * post_t$		0.2715*			0.2035	
		(0.1492)			(0.1381)	
$nonMMF_i * stable_j * post_t * newReln_{ij}$		-0.5411**			-0.5278**	
		(0.2372)			(0.2447)	
$nonMMF_i * big_j$			0.0792			0.0542
			(0.0514)			(0.0512)
$nonMMF_i * big_j * post_t$			-0.1392**			-0.1143**
			(0.0612)			(0.0548)
$nonMMF_i * big_j * post_t * newReln_{ij}$			0.0124			0.0346
			(0.0647)			(0.0645)
Highest quote	0.7652***	0.7647***	0.7644***	0.7486***	0.7478***	0.7483***
	(0.0230)	(0.0229)	(0.0231)	(0.0239)	(0.0239)	(0.0240)
N	5831	5831	5831	6189	6189	6189
R^2	0.6786	0.6797	0.6789	0.6617	0.6626	0.6619
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1, if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OB2 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Table OB3

Winning bid - Placebo tests post-reform period

	(1)	(2)	(3)	(4)	(5)	(6)
Period length:	3 months	3 months	3 months	3 months	3 months	3 months
Pre-period from:	14/01/2016	14/01/2016	14/01/2016	14/01/2016	14/01/2016	14/01/2016
to:	13/04/2016	13/04/2016	13/04/2016	13/04/2016	13/04/2016	13/04/2016
Post-period from:	14/04/2016	14/04/2016	14/04/2016	14/07/2016	14/07/2016	14/07/2016
to:	13/07/2016	13/07/2016	13/07/2016	13/10/2016	13/10/2016	13/10/2016
$nonMMF_i * post_t$	-0.0006	0.0700	0.1467**	-0.0374*	0.0101	0.1037
	(0.0184)	(0.0445)	(0.0593)	(0.0193)	(0.0455)	(0.0944)
$nonMMF_i * post_t * newReln_{ij}$	0.0460*	1.1630***	1.1669***	0.0298	-1.8133***	0.0177
	(0.0258)	(0.1819)	(0.1801)	(0.0208)	(0.0525)	(0.0200)
$nonMMF_i * stable_j$		0.0602			0.0262	
		(0.0551)			(0.0527)	
$nonMMF_i * stable_j * post_t$		-0.0885*			-0.0602	
		(0.0507)			(0.0559)	
$nonMMF_i * stable_j * post * newReln_{ij}$		-1.1477***			1.8580***	
		(0.1733)			(0.0639)	
$nonMMF_i * big_j$			0.2343**			0.2219**
			(0.0919)			(0.0834)
$nonMMF_i * big_j * post_t$			-0.1612***			-0.1635
			(0.0595)			(0.1055)
$nonMMF_i * big_j * post_t * newReln_{ij}$			-1.1733***			0.0000
			(0.1690)			(.)
$highestQuote_{ab}$	0.7732***	0.7744***	0.7741***	0.7523***	0.7527***	0.7526***
	(0.0206)	(0.0208)	(0.0208)	(0.0222)	(0.0224)	(0.0222)
N	6151	6151	6151	6509	6509	6509
R^2	0.7062	0.7073	0.7085	0.6882	0.6896	0.6893
Bank and auction controls	✓	✓	✓	✓	✓	✓
Bank FE	✓	✓	✓	✓	✓	✓
Firm-month FE	✓	✓	✓	✓	✓	✓

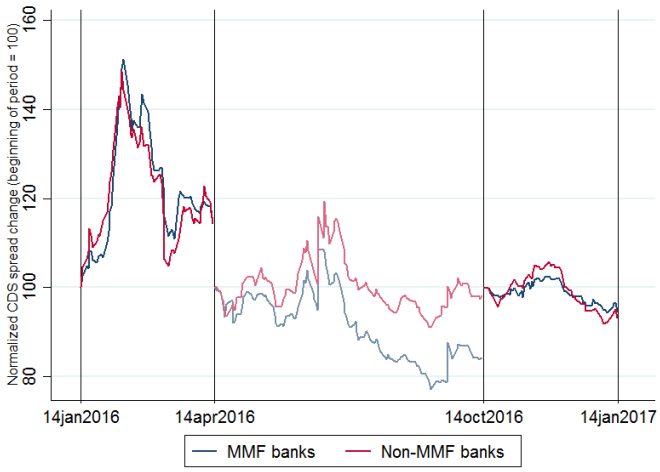
Notes: OLS regressions for Equation 4. The dependent variable is $WinningBid_{ijabt}$ defined as a dummy variable that equals 1 if bank i wins the deposit offered by firm j in auction a with bid b at time t. $nonMMF_i$ is a dummy variable equal to 1 if a bank is non-MMF and $post_t$ a dummy variable equal to 1 in the post-reform period. $newReln_{ij}$ is a dummy variable equal to 1 if the first transaction (determined considering all currencies traded on the platform) between a bank i and firm j takes place after April 2016. $stable_j$ is equal to one if firm j offering the deposit is a stable funding provider according to the aforementioned definition. big_j is equal to 1 if the average transactions size of firm j is larger or equal to the median of average transaction sizes of all other firms. $highestQuote_{ab}$ is a dummy variable equal to 1 if bid b contains the highest quote in auction a. Auction controls include the logarithm of the notional deposit amount and the remaining time (in days) until the funding matures; bank controls include the lagged logarithm of bank total assets, leverage (total assets over equity) and the share of net interest income of bank's total revenue. Each column uses a distinct sample according to the pre-reform and post-reform period specifications in the table header. See Figure OB3 for a visual representation of the periods setup. Standard errors are clustered at the bank level and given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Online Appendix OC Brexit and CDS spreads

Figure OC1

Average CDS spread change

Excluding top 10% of banks most severely hit by Brexit (7 banks) & excluding UK banks



Notes: Daily CDS spread changes normalized to the beginning of each sub-period (=100). US banks excluded.

Table OC1

Regression on CDS spread changes

Excluding top 10% of banks most severely hit by Brexit (7 banks) & excluding UK banks

	(1)	(2)	(3)
$nonMMF_i$	-11.0747	-15.7805	
	(16.6161)	(15.1915)	
$nonMMF_i * post_t$	14.8496	10.5568	1.0237
	(17.7479)	(15.6218)	(17.4164)
$Brexit * post_t$	-0.4615*	-0.4701	-0.4937
	(0.2591)	(0.2790)	(0.5018)
N	58	58	58
R^2	0.6138	0.6650	0.8645
Banks controls	✓	✓	✓
Country-period FE	✓	✓	✓
Bank FE			✓

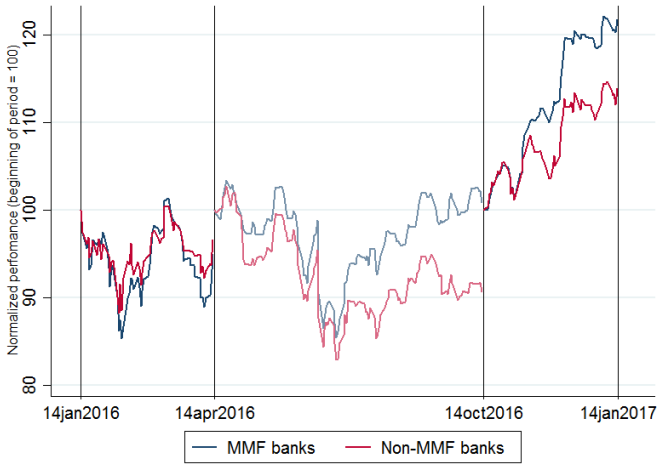
Notes: OLS regressions for Equation 9. The dependent variable is $CumCDSspreadChange_{ikt}$ defined as cumulative CDS spread change of bank i from country k in pre-reform or post-reform period of three months length. $nonMMF_i$ is a dummy variable equal to 1 if a bank is a non-MMF bankand $post_t$ a dummy variable equal to 1 in the post period. $Brexit$ is defined as the CDS spread change in percentage points two trading days after the referendum and is equal to 0 for observations in pre-reform period. Bank controls encompass the logarithm of bank total assets, the leverage defined as total assets over equity, and the share of NII of total revenue. Robust standard errors are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

Online Appendix OD Brexit and stock returns

Figure OD1

Average stock price performance

Excluding top 10% of banks most severely hit by Brexit (5 banks) & excluding UK banks



Notes: Daily stock price performance normalized to the beginning of each sub-period (=100). US banks excluded.

Table OD1

Regression on stock price performance

Excluding top 10% of banks most severely hit by Brexit (5 banks) & excluding UK banks

	(1)	(2)	(3)
$nonMMF_i$	4.1796	0.0934	
	(7.1454)	(6.3670)	
$nonMMF_i * post_t$	-21.9877***	-20.3776***	-16.6385
	(6.4024)	(6.3524)	(10.0557)
$BrexitDrop * post_t$	0.8021***	0.9677***	1.5193***
	(0.2011)	(0.2679)	(0.4686)
N	56	56	56
R^2	0.9270	0.9326	0.9580
Banks controls	✓	✓	✓
Country-period FE	✓	✓	✓
Bank FE			✓

Notes: OLS regressions for Equation 9. The dependent variable is $CumStockReturn_{ikt}$ defined as the three months cumulative stock return of bank i from country k in pre or post period of three months length. $nonMMF_i$ is a dummy variable equal to 1 if a bank is a non-MMF bankand $post_t$ a dummy variable equal to 1 in the post period. $BrexitDrop$ is defined as the stock price drop in percentage points two trading days after the referendum and is equal to 0 for observations in pre-period. Bank controls encompass the logarithm of bank total assets, the leverage defined as total assets over equity, and the share of NII of total revenue. Robust standard errors are given in parentheses. ***, **, * indicate significance at the 1%, 5% and 10% levels.

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