Currency Mispricing and Dealer Balance Sheets*

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Abstract

We relate currency mispricing originating from the breakdown of covered interest rate parity to the dealer balance sheet constraints resulting from the post-crisis financial regulation. Using a unique dataset on contract-level foreign exchange derivatives with disclosed counterparty identity, we find that dealers demand an additional premium from their clients for synthetic dollar funding when their leverage ratio increases. We handle endogeneity using two exogenous variations associated with the public disclosure of the leverage ratio, and the introduction of the UK leverage ratio framework while controlling for demand shocks at the client level. We also use hedging demand shocks and find that these shocks have a larger impact on currency mispricing, the higher the leverage ratio. Finally, we document that central banks have the tendency to trade against currency mispricing whereas hedge funds display a mixed behavior.

Keywords: Exchange rates, dollar basis covered interest parity condition, arbitrage opportunities.

JEL Classification: F31, G12, G15.

"We need to better understand what underpins the supply and demand that determines the basis and what causes those two curves to shift. Who are the relevant participants and what, if any, constraints might they have on their behaviour?"

— Guy Debelle (2017), Deputy Governor of the Reserve Bank of Australia

1 Introduction

Market participants argue that the regulatory framework introduced in the wake of the global financial crisis has increased the costs of financial intermediation. The leverage ratio rule, by limiting the size of a bank's balance sheet relative to its capital, is under the spotlight as it affects the market making of balance-sheet-intensive businesses. A Reuters article on 5 August 2013 voiced, for example, that *"[A]t the end of the day the Basel Committee has put aside some three decades of oversight based on risk-weighted assets in favour of a blunt measure of total leverage—with all kinds of unintended consequences the likely result."*

We show that the additional funding cost faced by international investors to borrow dollars through the foreign exchange (FX) market is directly linked to the leverage ratio requirement of dealer banks, and can be seen as an unexpected side effect of the post-crisis financial regulation. In our exercise, we shed light on the causal relationship using supervisory data on dealer banks matched with contract-level data on FX swaps and forwards with counterparty information, a critical ingredient to isolate factors affecting the supply side from those affecting the demand side. For identification, we employ the UK leverage ratio framework, introduced two years ahead of the Basel Committee's proposal, as a plausible exogenous variation affecting some of the major dealer banks. We find that dealer banks charge an extra premium to their clients for synthetic dollar funding (or equivalently dollar hedging) when the leverage ratio becomes more binding. Intuitively, the leverage ratio makes it costly for banks to engage in low margin activities that require high turnover to be profitable, as the intermediation of FX swaps and forwards effectively expands a bank's balance sheet. This expansion of their balance sheet happens as dealer banks are unable to net positions across different counterparties for the calculation of their regulatory leverage exposure.

Figure 1 about here

Since "a picture is worth a thousand words", we provide an illustrative example in Figure 1. We display the median leverage ratio of major dealer banks operating in London (the global hub for FX trading) and the one-month "dollar basis", i.e. the difference between dollar lending rates in the US money market and FX swap market, on the euro and the Japanese yen against the dollar. This basis represents an apparent deviation from covered interest parity (CIP), which is the law of one price applied to the FX market, the largest financial market in the world. The basis widened substantially in 2014–2016, reaching more than 100 basis points per annum. The chart illustrates the narrative put forward by many market participants: the basis widened during a period in which dealers deleveraged significantly, as banks faced tighter regulatory leverage constraints arising from the introduction of the UK leverage ratio framework in 2016.

Testing a causal link between the leverage ratio and the dollar basis, however, is challenging as both may be driven by common, perhaps unobserved, factors. While there is some evidence that attributes the existence of the dollar basis to dealers' balance sheet costs and hedging demand pressure, the debate is far from being conclusive as the existing literature relies on aggregate data that prevent a neat identification of the determinants of the dollar basis (e.g., Du, Tepper, and Verdelhan, 2018; Sushko, Borio, McCauley, and McGuire, 2016; Rime, Schrimpf, and Syrstad, 2017). For example, Du, Tepper, and Verdelhan (2018) argue that spikes in the dollar basis at quarter-ends provide evidence that CIP deviations are larger when leverage constraints become more binding. As He and Krishnamurthy (2018) argue, in the FX market one is typically constrained by the observation of only one price for the forward contract, so that studies so far have only shown impacts of leverage regulation to the aggregate supply curve for forwards, which usually involves studying single time series of capital and forward prices. This paper attempts to fill this important gap in the literature. Our unique dataset allows us to identify FX supply curve at the dealer level, something that was previously impossible in the exchange rate literature.

Second, we contribute to the literature also by quantifying the impact of a change in one percentage point in a dealer-level leverage ratios on the basis. Studies so far have only shown a plausible impact of leverage regulation on the dollar basis, but haven't quantified such impact.

This contribution is important for policy-makers as it can help them improve the calibration of the leverage ratio framework. For academics, quantifying the impact is important because, as He and Krishnamurthy (2018) point out in the context of intermediary asset pricing models, "ultimately for model construction, it is necessary to know how a reduction of say x% capital impacts supply."

In addition to being large, the dollar basis is also economically important. A recent study by Borio, McCauley, and McGuire (2017) estimate an outstanding amount of $52 trillions borrowed via FX swaps, outright forwards and cross-currency swaps as of December 2016. With an average basis of 40 basis points per annum, a back-of-the-envelope calculation would imply an extra borrowing cost of more than $200 billions per annum for global investors. Understanding the drivers of the dollar basis is key for both policy makers and market participants. A large basis between onshore and offshore dollar funding rates could, for instance, lead financial institutions to sell assets at distressed prices under adverse circumstances. This might affect their solvency and, in turn, pose a threat to the stability of the global financial system.

Our analysis employs contract-level data on forward exchange rates (outright forwards and forward legs of FX swaps) for six major currency pairs relative to the US dollar, i.e., Australian dollar, Canadian dollar, Swiss franc, euro, British pound, and Japanese yen. We use all over-the-counter transactions, with at least a UK legal entity as a counterparty, reported to the Depository Trust & Clearing Corporation Derivatives Repository (DTCC) between December 2014 and December 2016. This reporting obligation is mandatory since 2014 under the European Market Infrastructure Regulation (EMIR). The dataset comprises more than 17 million transactions of which we observe counterparty information and contract characteristics, and covers up to about 43% of the global daily trading activity surveyed in the BIS Triennial Survey (BIS, 2016). Our contract-level forward rates are then synchronized with quotes on spot exchange rates and overnight index swap (OIS) rates from Thomson Reuters Tick History.[1] This exercise allows us to construct contract-level dollar basis whereby only

[1] While forward prices are available at different maturities, OIS rates are only available at fixed maturities between one week and three months. As a result, we only focus on dollar basis (or equivalently CIP deviations) falling within this maturity spectrum and linearly interpolate OIS rates using the closest available tenors for non-standard maturities.

the forward price differs across parties, consistent with view that a non-zero basis is primarily caused by shifts in the supply and/or demand of forwards (Du, Tepper, and Verdelhan, 2018; Sushko, Borio, McCauley, and McGuire, 2016).

We then match our contract-level dollar basis with the leverage ratio of major dealer banks under the supervision of the Bank of England. Leverage measures by how much a bank funds its assets with debt as opposed to equity and the incentive to use some degree of leverage comes from the fact that debt is a cheaper source of funding. Excessive leverage in the banking sector, however, was arguably among the causes of global financial crisis, and this led the Basel Committee to recommend the introduction of a minimum leverage ratio requirement, independent of any risk assessment, to act as a backstop measure to risk-based rules (BCBS, 2010). This measure is quantified as Tier 1 capital in the form of common shares and disclosed reserves over total consolidated assets measured as on- and off-balance sheet items including derivatives exposures (BCBS, 2014). This risk-insensitive balance-sheet constraint has raised concerns as banks may refrain from engaging in the market-making of large-scale less rewarded activities, thus raising their warehousing costs (e.g., CGFS, 2014; ESRB, 2016; CGFS, 2016). Despite its importance in terms of regulation design, there is limited empirical evidence that sheds lights on the causality of these claims.

We first measure the impact of the leverage ratio of dealer banks on the dollar basis. For this exercise, we regress contract-level dollar basis on the lagged leverage ratio of dealer banks, while controlling for different time-variant and time-invariant factors via fixed effects. Since different segments of the market (e.g., hedge funds as opposed to non-financial corporates) may respond to different type of demand shocks (e.g., funding costs or regulatory standards), we categorize the client segment into real money investors, hedge funds, non-financial corporates, non-dealer banks, and central banks; then we control for sector-time fixed effects to capture time-variant and time-invariant unobserved sector-related factors. We find that a one standard deviation increase in the leverage ratio is associated with a larger dollar basis of about 20 basis points. In contrast, the risk-weighted capital ratio of dealer banks, a capital adequacy measure introduced by the Basel Committee since the late '80, displays no significant relationship with the dynamics of the dollar basis.

Working with highly granular contract-level observations does not allow us to account fully for changes in demand conditions. For instance, demand for dollar funding via FX swaps (or, equivalently, demand for hedging dollar risk forward) may vary within a given client sector and so we would be unable to give a supply interpretation to our estimates. We address this identification challenge using the methodology pioneered by Khwaja and Mian (2008), i.e., we introduce client-time fixed effects to absorb client-specific changes in demand. For its implementation, we collapse our contract-level dollar basis into volume-weighted weekly data in order to have clients with multiple trading relationships. This approach removes all confounding demand factors and is equivalent to asking whether the same counterparty in the same time period dealing with multiple dealer banks faces a larger basis from the dealer bank with a relatively higher leverage ratio.

In addition to controlling for client-related factors, we should also account for possible omitted bank-related variables. For instance, a higher leverage ratio could result from active balance sheet management as opposed to a binding regulatory constraint. We improve our identification by using a difference-in-differences approach based on plausibly exogenous variation arising from the introduction of the UK leverage ratio framework in January 2016 for major UK banks.[2] While the minimum requirement could have been anticipated, we indeed exploit a change in how regulated banks had to report their leverage ratio since there was no incentive for them to adjust the reporting requirement prior to its actual change. Following a transitional period of twelve months, covered by our sample, affected banks were required to quantify their capital measure and asset exposure on the last day of each month and then average over the reference quarter. Other banks, in contrast, continued to measure their non-binding leverage ratio on the last of each quarter as prescribed by the EU legislation. This shift from end of quarter to monthly average reduced the ability of affected banks to window-dress their balance sheet at period ends and effectively made the leverage ratio more binding. In our experiment, UK dealer banks constitute the *treatment group* whereas the subsidiaries of international banks the *control group*. Using a the pre- and post-regulatory sample, we document an increase of 24 basis points in the dollar basis for affected dealer banks which

[2] The UK framework was announced in December 2015 and become mandatory for major UK banks in January 2016, ahead of the Basel Committee proposal (Bank of England, 2015b).

confirms the role of the regulatory leverage ratio requirement as a key determinant of the dollar basis. Put it differently, as the leverage ratio become more binding, regulated dealer banks face higher intermediation costs which translate into wider dollar basis. A placebo test around a post-regulatory date, moreover, shows that the parallel trend assumption behind our methodology is at work.

We also consider an alternative difference-in-differences exercise to enhance our identification strategy. We test whether the dealer banks with the lowest leverage ratio prior to the policy debate on excessive leverage in the banking sector (e.g., Draghi, 2008; G20 Summits, 2008) have experienced the largest dollar basis following the introduction of the leverage ratio rule. We measure the leverage ratio of dealer banks in December 2007, albeit naïvely as shareholders' claims to total assets using published accounts (see, for instance, Bank of England, 2015a). Hence, we use its cross-sectional median value to form a *treatment group* (below the median) and a *control group* (above the median) of dealer banks. We then perform a difference-in-difference exercise around January 2015, a date that marked the beginning of public disclosure for leverage ratio (BCBS, 2014). Despite there was no minimum requirement at the time, one could argue that banks had an incentive to adjust their leverage ratio around the expected minimum requirement to avoid, for instance, any reputation costs as soon as public disclosure become effective.[3] We uncover an increase in dollar basis evolving around 36 basis points for treated dealer banks compared to untreated dealer banks, after absorbing for changes in demand conditions. Our results remain unchanged if we rank banks on the basis of the average leverage ratio between 2000 and 2007. Overall, we confirm the role of the leverage ratio requirement as a determinant of the dollar basis.

With the richness of our dataset, we can also examine the behaviour of client demand. We construct a measure of order flow using buy and sell orders that dealers receive from their client sectors and find evidence of clients' heterogeneity across different maturities. We uncover a net demand of dollars for all currency pairs across different maturities. In

[3]The Basel Committee (BCBS, 2009a) defines reputation risk as "the risk arising from negative perception on the part of customers, counterparties, shareholders, investors, debt-holders, market analysts, other relevant parties or regulators that can adversely affect a bank's ability to maintain existing, or establish new, business relationships and continued access to sources of funding (e.g., through the interbank or securitisation markets)."

particular, real money investors (i.e., asset managers, pension funds and insurance companies) and non-financial corporate firms display a strong net demand for dollars while central banks act as arbitrageurs by supplying dollars on average. Hedge funds, moreover, are net consumer of dollars in short-term (i.e., less than 3-month maturity) and net supplier of dollars for longer-term maturity contracts. In contrast, non-dealer banks behave as net suppliers in the short-term (i.e., less than 1-month maturity) and net consumer of dollars for longer-term maturity contracts.

We then consider the effect of demand factors and the interaction with the leverage ratio of dealer banks. First, we find that an increase in the aggregate net demand of dollars (or order flow) is associated with a larger dollar basis, the higher the leverage ratio. Intuitively, the leverage ratio steepens the supply curve of dealer banks, with more constrained banks requiring a higher compensation to take the other side of a trade due to increased hedging demand. Second, we study the changes of the dollar basis around monetary policy announcements which proxy for exogenous shocks to the hedging demand of international investors. Similarly to the previous exercise, we find that a larger monetary policy shock is associated with a larger dollar basis, especially when the leverage ratio is higher. Lastly, we examine the dollar basis around the implementation of the US money market fund reform in October 2016. This event represents a shock to the supply of dollars to market participants in the cash instrument market (e.g., commercial paper). In turn, these participants tapped the FX swap market to get dollar funding. The data suggests that the larger the leverage ratio of dealer banks, the wider the basis after this reform. In brief, we conclude that demand factors have a second-order effect on the dollar basis.

Finally, while most of the analysis evolves around short-term (i.e., less than a year maturity) dollar basis, we also show that the cross-currency basis swap spread, analogous to long-term CIP deviations, is directly associated with balance-sheet constraints, especially in the form of risk-weighted capital requirements. Using transaction-level regressions, we find that an increase in the capital ratio is associated with a widening of the basis during the next following quarter. This result is consistent with the fact that long-term contracts tend to have higher risk weight in the calculation of the regulatory capital ratio (e.g., Du, Tepper, and Verdelhan, 2018)).

The dollar basis measures the spread between the dollar interest rate from the money market and the synthetic dollar interest rate from the swap market. The latter is obtained by converting foreign currency into dollar while simultaneously hedging currency risk using a forward contract. When the basis deviates from zero, CIP is no longer valid. While this no-arbitrage condition has worked fairly well in the data for more than three decades (e.g., Frenkel and Levich, 1975; Clinton, 1988; Akram, Rime, and Sarno, 2008), its validity was severely compromised during the financial crisis of 2007–2008 when an unprecedented US dollar funding shortage primarily attributed to funding liquidity and counterparty risk materialized (e.g., Baba and Packer, 2009; Coffey, Hrung, and Sarkar, 2009).[4] Despite a significant improvement in market conditions, recent years have been characterized again by large and systematic arbitrage deviations. Du, Tepper, and Verdelhan (2018) find that credit risk and transaction costs fail to explain the existence of persistent CIP deviations. The authors instead document that one-week and one-month CIP deviations are more pronounced at quarter-ends starting from January 2015 when the public disclosure of the leverage ratio for European banks started. Tightened balance sheet constraints at quarter ends, then, are interpreted as a sign that banking regulation translates into wider arbitrage deviations. Similarly, Sushko, Borio, McCauley, and McGuire (2016) identify the increase in FX hedging demand on one side and limits to arbitrage due to higher balance sheet costs on the other side as potential explanations. Rime, Schrimpf, and Syrstad (2017) instead argue that market segmentation and funding liquidity premia play an important role as only global international banks can enjoys risk-less arbitrage opportunities. We see our paper as complimentary to this literature. We are among the first to examine actual trading activity of different market participants and show that CIP deviations are not arbitraged away when major dealer banks face tighter balance sheets constraints.

Our findings are consistent with the growing literature on intermediary asset pricing (Brunnermeier and Pedersen, 2009; He and Krishnamurthy, 2013; Adrian, Etula, and Muir, 2014;

[4] The literature evaluating the validity of CIP is vast and includes, among many others, Frenkel and Levich (1977); Rhee and Chang (1992); Baba, Packer, and Nagano (2008); Fong, Valente, and Fung (2010); Mancini-Griffoli and Ranaldo (2012); Buraschi, Menguturk, and Sener (2015); Ivashina, Scharfstein, and Stein (2015); Avdjiev, Koch, Shin, and Du (2016); Iida, Kimura, and Sudo (2016); and Liao (2016).

He, Kelly, and Manela, 2017). Our results indeed suggest that financial intermediaries play an important role in the pricing of financial assets. For example, Adrian, Etula, and Muir (2014) show empirically that the *leverage* (which is the inverse of the *leverage ratio* according to the regulatory definition) of broker-dealers is a good proxy for the marginal utility of financial intermediaries. They explain their findings based on the model by Brunnermeier and Pedersen (2009): when funding constraints are tight, intermediaries are forced to deleverage, so that when intermediaries' leverage is low (that is when the leverage ratio is high), their marginal value of wealth is high and therefore the required return for holding a risky asset is higher. Our results are also related to the literature on limits to arbitrage (for a survey, see Gromb and Vayanos, 2010). In particular, Gromb and Vayanos (2018) propose a model in which arbitrageurs have limited capital, which constrains their activity and in turn gives rise to multiple pricing anomalies, including CIP deviations.

We also contribute to the literature on the impact of financial regulation on asset markets. Adrian, Boyarchenko, and Shachar (2017) argue that post-crisis regulation had and averse impact on the liquidity of US corporate bonds. Bicu, Chen, and Elliott (2017) find that liquidity in the UK government bond and repo markets deteriorated after the introduction of the leverage ratio rule. Cenedese, Ranaldo, and Vasios (2018) show that recent regulation introduced heterogeneity in the pricing of interest rate swaps. Kotidis and van Horen (2018) report that the leverage ratio negatively affects dealer-client repo intermediation.

The remainder of this paper is organized as follows. Section 2 reviews CIP condition and the recent regulatory changes. Section 3 provides a detailed a description of the data and explains the construction of the transaction-level CIP deviations. Section 4 links CIP and balance sheet costs whereas Section 5 examines the interaction between demand and supply factors. Section 6 examines the long-term dollar basis based on cross-currency swaps before concluding in Section 7.

2 Background

2.1 Failure of Covered Interest Rate Parity

The covered interest rate parity (CIP) condition is the statement that the real cost of funding on the cash market should be equal to the implied cost of funding in the FX swap market. Equivalently, from the perspective of a US investor, if CIP holds, lending dollars in the domestic cash market should yield the same payoff as converting dollars into foreign currency at the prevailing spot exchange rate, investing that amount in the foreign cash market, and hedging the FX risk by selling foreign currency for dollars in the forward market. This strategy is often implemented via an FX swap contract, which incorporates both the spot and forward transactions in the same contract. In what follows, we refer to FX swaps and the combination of spot and forward contracts interchangeably.

More formally, the CIP condition states that the following equality should hold:

$$1 + i_t = (1 + i_t^*)\frac{F_t}{S_t}, \tag{1}$$

where S and F indicate, respectively, the spot and forward price of foreign currency expressed in US dollars; i is the dollar interest rate, whereas i^* is the foreign interest rate. The interest rate maturities match that of the forward contract. For ease of exposition, we abstract from different contract maturities and bid and ask prices in the formula. Moreover, this textbook parity condition ignores the riskiness of the cash and forward/swap contracts and assumes absence of credit, liquidity, and settlement risk.

If the equality is violated, then an arbitrage opportunity exists, as an investor could invest in the higher-yielding rate by funding herself with the lower-yielding rate at no risk. As a concrete example, suppose that the US-dollar risk free rate (the left hand side of Equation 1) is lower than the implied dollar return on investing in, say, the euro swap market (the right hand side of the same equation). Then an arbitrageur would make a positive payoff by borrowing in US dollars at interest cost i_t, exchanging the sum to euros at the spot exchange rate S_t, lending the proceeds in euros at the rate i_t^*, and at the same time entering in a forward contract to exchange (at the prevailing forward rate F_t) the principal and accrued interest back to US dollars at maturity to repay the original loan. Formally, the CIP deviation can be then defined as

$$\delta_t = 1 + i_t - (1 + i_t^*)\frac{F_t}{S_t}, \tag{2}$$

and when it holds, the deviation δ_t is equal to zero.

As outright forwards and FX swaps are short-term instrument, the long-term CIP deviation based on Libor is given by the spread on the cross-currency basis swap. A cross-currency basis swap involves an exchange of cash flows linked to floating interest rates referenced to interbank rates in two different currencies, as well as an exchange of principal in two different currencies at the inception and the maturity of the swap. The cross-currency basis swap spread can be interpreted as the analogous of long-term CIP deviations (Du, Tepper, and Verdelhan, 2018).

2.2 Post-crisis Financial Market Regulation

Since the 2007-2008 global financial crisis, policy makers and regulators have embarked in a significant program of financial reforms to strengthen the resilience of the banking sector, ultimately to reduce the transmission of spillover effects from the financial sector to the real economy. Among these reforms, a key role is played by the new international regulatory framework on bank capitalization, stress testing, and market liquidity risk announced by the Basel Committee on Banking Supervision in July 2010, generally referred to as the 'Basel III' accord (e.g., BCBS, 2009b, 2010).

As part of this comprehensive package, the Basel Committee proposed a non-risk weighted regulatory metric – the leverage ratio requirement – according to which banks have to hold capital in proportion to the overall size of their balance sheet exposure. Such a simple rule was motivated by the need to curb the accumulation of excessive leverage and lessen the destabilizing effects associated with the deleveraging process experienced by the banking sector during the global financial crisis.

Per se, the leverage ratio is calculated as a capital measure divided by an exposure measure, and is expressed as a percentage. The numerator consists of high quality loss-absorbing (Tier 1) capital whereas the denominator includes on-balance sheet exposures, derivatives exposures, securities financing transactions exposures, and off-balance sheet items (e.g., BCBS, 2014). By weighting all exposures equally as opposed to the existing capital ratio which takes assets' riskiness into consideration,[5] the leverage ratio is potentially raising the costs for banks to engage in the market-making of assets characterized by high volumes and low margins (e.g., CGFS, 2014). This is particularly the case for FX derivatives as their margins are fairly low compared to other line of business but their transaction volume substantially expands a dealer bank's balance sheet thus attracting a capital charge under the leverage ratio framework. For derivatives, moreover, banks have a limited capability to net out exposure that offset each other across different counterparties. This happens as derivatives generate two types of exposures, i,e., an exposure originating from the underlying of the derivative contract and a counterparty credit risk exposure (e.g., BCBS, 2014).

The Basel Committee began phasing in the leverage ratio requirement with a transition process that started in January 2013 with national supervisors tracking the leverage ratio and its components, and continued with banks publicly disclose their leverage ratio starting from January 2015 (BCBS, 2010). The definition of the leverage ratio was only finalized in May 2014 (BCBS, 2014) with the view to introduce a mandatory minimum requirement of 3% from January 2018.In each jurisdiction, however, the implementation of the leverage ratio requirement has been delegated to national regulators.[6]

Figure 2 about here

[5]The capital ratio is defined as capital over risk-weighted assets and the weight assigned to a given asset reflects the relative risk of incurring loss. For example, under Basel I capital rules, risk weights were 1 for corporate lending, 0.5 for household lending and 0 for government lending. Under the new Basel II rules, risk weights depend on the credit and market risk of the portfolio. A measure of market risk used in the Basel framework is the value-at-risk (VaR) based on 10-day holding period returns. The revision of Basel II norms has introduced a VaR requirement calibrated over a stress period. The minimum internationally agreed Tier 1 capital requirement is 6% of risk weighted assets.

[6]Basel III has been introduced in the EU through the Capital Requirement Directive IV (CRD IV), a legislative package covering prudential rules for banks, building societies and investment firms. It is made up of the Capital Requirements Directive (2013/36/EU) (CRD) which must be implemented through national law, and the Capital Requirements Regulation (575/2013) (CRR) which is directly applicable to firms across the EU. This legislation is applicable since January 2014 and the leverage ratio is mandatory starting from January 2018.

In the UK, for instance, the leverage ratio framework has been implemented ahead of the Basel Committee's proposal. In particular, major UK banks were encouraged to disclose their leverage ratio since 2013 following a recommendation of the Financial Policy Committee (FPC) to the Financial Services Authority in December 2011 (see, Bank of England, 2011), and expected to meet a minimum 3% leverage ratio calculated on an end-of-quarter basis since January 2014 as a result of supervisory statement of the Prudential Regulation Authority (PRA) in November 2013 (see, Bank of England, 2013). In October 2014, as part of a leverage ratio review process requested by the government for a sufficiently resilient banking system, the FPC recommended the introduction of a 3% minimum leverage ratio plus two macroprudential buffers for major UK banks as soon as practicable (see, Bank of England, 2014). In July 2015, the FPC directed the PRA to start a consultation process on the implement a leverage ratio framework following a government mandate that gave the FPC powers of direction over leverage ratio requirements in April 2015.

The UK leverage ratio framework was formally announced in early December 2015 when the PRA set the final rules for the calculation of the leverage ratio and its key components. The leverage ratio requirement is mandatory for major UK banks (those with deposits over £50 billion) since January 2016 and comprises a *minimum leverage ratio requirement* of 3% (three quarters of which must be met with common equity Tier 1 capital instruments), a *countercyclical leverage ratio buffer* (CCLB) equal to 35% of the bank's countercyclical capital buffer, and an *additional leverage ratio buffer* (G-SII ALRB) that applies to global systemically important institutions and equal to 35% of the bank's systemic importance buffer (see, Bank of England, 2015c,b). Regarding the reporting requirements, the PRA introduced a transition period of 12 months during which the end-of-quarter leverage ratio is calculated as the the arithmetic mean of the bank's leverage ratio on the last day of each month during the reference quarter. Starting from January 2018, major UK banks will be subject to the daily average rule for the calculation of the end-of-quarter leverage ratio to prevent banks engaging in short-term balance sheet management activities. Other PRA-regulated banks, i.e., small domestic banks and foreign banks' subsidiaries, remain subject to a 3% minimum leverage ratio requirement from January 2018 under the EU legislation. We present the key dates leading to the introduction of the UK leverage ratio framework in Figure 2.

3 Data Description and Preliminary Analysis

This section presents a detailed description of the trade repository data before turning to the construction of contract-level dollar basis which we use in our empirical analysis.

3.1 Trade Repository Data

Description. Over-the-counter (OTC) derivatives markets are generally regarded as the most opaque financial markets. Understanding the complexity and the functioning of these "dark markets" (e.g., Duffie, 2012) is notoriously difficult as buyers and sellers negotiate the terms of the trade privately. Not surprisingly, financial regulators have struggled for a long time to gather key information such as price, volume, maturity, outstanding transactions and counterparty identities. The recent global financial crisis, however, marked an important turning point as G20 leaders put forward in September 2009 a broad reform agenda to profoundly improve the level of transparency in these markets. As part of this initiative, it was agreed that all OTC derivatives contracts should have been reported to trade repositories in order to grant policy-markers and regulators access to high-quality and high-frequency data.

In the European Union, this commitment was introduced with the European Market Infrastructure Regulation (EMIR). Since February 2014, it has been mandatory for counterparties resident in the European Union to report by the following business day the details of any derivative transactions to a trade repository authorized by the European Securities and Markets Authority (ESMA).[7] This reporting obligation covers both over-the-counter and exchange-traded derivatives, comprises all asset classes – credit, commodity, equity, interest rates and foreign exchange (FX) – and applies to clearing houses, financial counterparties and non-financial counterparties that are legal entity under the jurisdiction of the European Union.[8]

[7] The list of registered trade repositories includes (i) CME Trade Repository Ltd., (ii) Depository Trust & Clearing Corporation (DTCC) Derivatives Repository Ltd., (iii) ICE Trade Vault Europe Ltd., (iv) Krajowy Depozyt Papierów Wartościowych S.A., (v) Regis-TR S.A., (vi) UnaVista Limited (UnaVista), and (vii) Bloomberg Trade Repository Limited. See here for more details.

[8] A similar reform in US, for instance, has been implemented trough the Dodd-Frank Wall Street Reform

While the reporting obligation has been introduced since February 2014, a large number of observations were initially missing or incorrectly reported. In response to this issue, ESMA introduced a formal process of data validation in December 2014 which substantially improved the quality of the data. For instance, Abad, Aldasoro, Aymanns, D'Errico, Rousova, Hoffmann, Langfield, Neychev, and Roukny (2016) use month-end data from DTCC and find that the percentage share of missing variable was about 30% before the introduction of the validation process. After this date, the percentage share of missing variable has sharply dropped below 10% and since then there has been a clear downward trend. Guided by this information about data quality, our sample starts in December 2014 and ends in December 2016.

Within the OTC derivatives market, FX derivatives represent the largest segment in terms of daily transaction volume and the second-largest segment in terms of notional value after interest rate derivatives (see BIS, 2016). Our dataset consists of contract-level outright forwards and forward legs of FX swaps, which we refer to as forward contracts. While the outright forward is an agreement to exchange two currencies on a future date at a rate agreed on the inception date, the FX swap comprises an initial transaction of two currencies, typically at the spot rate, coupled with the commitment to reverse the transaction on a future date at the forward rate. The latter are generally used by dealers to manage their inventories, by asset managers to invest in foreign money markets without taking FX risk on board, and by central banks to manage their reserves liquidity. In contrast, the former are largely used as hedging instruments by exporters and as currency overlay tools by financial institutions. Despite these contracts are driven by different motives, no information is available in the EMIR data to discriminate one from the other as only the forward leg is reported for FX swaps.

We have been granted access to this highly granular dataset by Bank of England. In particular, we observe all derivatives transactions where at least one of the counterparty is a UK legal entity and rely on the reports submitted to the DTCC – the largest trade depository in terms of market share – as there exists a lack of data harmonization across trade reposi-

and Consumer Protection Act, or simply the Dodd-Frank Act. As of June 2016, according to the Financial Stability Board (FSB), 19 out of 24 FSB jurisdictions have enforced trade reporting requirements.

tories. Finally, we focus on the most liquid developed currencies – Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) – relative to the US dollar (USD).

Data Structure and Classification. We collect data from the "trade activity report" which contains for each transaction information about the counterparties (i.e., the Legal Entity Identifier (LEI) and the corporate sector) and the contract's characteristic (e.g., forward price, notional amount, type of delivery, maturity date, execution date, execution venue, execution time, currency cross) for a total of more than 100 fields. We then discard duplicates of the same transaction using the unique trade identifier as the EMIR imposes a double-sided reporting regime and we observe twice the same transaction when both counterparties are UK legal entities and both of them report to DTCC. In a number of cases, we have removed multiple copies of the same trade due to modifications, corrections and valuation updates. Finally, we drop any transactions with missing key information and remove observations with extreme notional values by winsorizing the data at 99.9% level. After processing and filtering more than a terabyte of data, our final dataset consists of roughly 17.2 million transactions – i.e., 34% (EUR), 21% (GBP), 15% (JPY), 13% (CAD), 11% (AUD), and 6% (CHF).

After the cleaning process, we proceed to the classification of individual counterparties. The FX market consists of two tiers: an interbank market where dealers (typically large international banks) trade among themselves and a retail segment where financial and non-financial clients trade either with dealers or other clients. In line with this characterization, we categorize individual counterparties into dealers and clients and then group their transactions accordingly. This process, however, was done largely manually as the LEI reference system does not provide any standardized source of classification of firms. Moreover, transactions are generally reported at the legal entity level thus implying that each subsidiary of large international banks, for instance, will separately report its transactions. As a result, we have consolidated a large number of single LEI reports to obtain transactions at the parent group level as in Cielinska, Joseph, Shreyas, Tanner, and Vasios (2017).

We classify the largest banks by overall market share according to the 2015 and 2016 Euromoney FX survey as dealers. Using this criterion, we end up with a list of 17 dealers which comprises (in alphabetic order) Bank of America Merrill Lynch, Barclays, BNP Paribas, Citi, Crédit Agricole, Credit Suisse, Deutsche Bank, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, Société Générale, Standard Chartered, State Street and UBS. This set of dealers is obtained by consolidating up to 106 different legal entities in the FX forward market. The remaining counterparties are treated as clients and manually split into real money investors (i.e., asset managers, pension finds, insurance firms, state institutions and unclassified funds), hedge funds, corporates, non-dealer banks (i.e., commercial banks, small dealers, prime brokerage firms and non-bank firms offering trading services), central banks (including monetary authorities) and unclassified clients (i.e., individual counterparties for which the LEI was either missing/incorrect or associated to an entity difficult to categorize). In our sample, we observe than 60,000 clients, i.e., 31% categorized as real money investors, 1% as hedge funds, 8% as corporates, 5% as non-dealer banks, less than 1% as central banks, and 52% as unclassified clients.[9]

The next step involves grouping transactions across different counterparties. We find that 39% of the 17.2 million transactions among dealers, 56% between dealers and clients (i.e., 17% with real money investors, 6% with hedge funds, 6% with corporates, 22% with non-dealer banks, less than 1% with central banks, and only 5% with unclassified clients), and about 5% among clients. The ratio between number of transactions and counterparties shows that hedge funds are on average the most active (with more than 2,800 transactions per entity) whereas real money investors are the least active (with nearly 160 transactions per entity) in the dealer-to-client segment. In between, we document approximately 1,100 transactions per entity for non-dealer banks, 480 for central banks, and 190 for corporates. The dealer-to-dealer segment, as one could expect, functions on a different scale as we uncover on average nearly 390,000 transactions per each dealer. The client-to-client segment, in contrast, is much less active as the average number of transactions per entity is about 225. In terms of maturity distribution, most of the trades are short term. Approximately 46% of the transactions have a maturity of no more than a week, 20% between 1-week and 1-month, 24% between 1-month and 3-months, and only 10% longer than 3-months.

[9] A number of unclassified LEIs are likely to refer to the same entity and this explains why its number is fairly large in absolute terms. As we document later in our analysis, they only account for about 2% of the total volume.

Preliminary Analysis. Since we employ a subset of the EMIR transaction-level data, one might be concerned that our data are not representative of the market trading activity. To shed light on the quality of our data, we compare at the outset of our analysis the aggregates of our data with the summary statistics reported in the 2016 Triennial Central Bank Survey of foreign exchange and OTC derivatives markets (BIS, 2016).

Figure 3 about here

Specifically, we measure daily forward volume (based on UTC execution dates) using all transactions recorded in our dataset, and report the comparison in Figure 3. As displayed in this figure, the daily average turnover as of April 2016 for the six currency pairs examined in our analysis is about 366 USD billions for outright forwards and 1.622 USD trillions for FX swaps, for a total amount of $1,988$ USD trillions, according to the Triennial Survey. In our dataset, we uncover an average daily volume of 844 (867) USD billions for both types of instruments as of April 2016 (full-sample period). Despite the comparison may be subject to errors due to different aggregation criteria, our calculations suggests that we observe more than 42% of the daily trading activity. This is consistent with the fact that London is the largest trading center for FX instruments (e.g., BIS, 2016).

Figure 4 about here

We also breakdown the volume by currency, maturity and sector. Figure 4 presents this decomposition for the FX forward market and reveals that a large fraction of the trading activity is dominated by the euro against the dollar, spans contracts up to a week maturity, and is concentrated in the interdealer market. In particular, the breakdown by currency pairs shows that approximately 39% of the total daily volume – or up to 340 USD billions per day – is about EUR against USD, an additional 41% is equally split between GBP and JPY, whereas AUD, CAD and CHF (all relative USD) cover a residual 20%. When we consider the breakdown by maturity, we find that more than 70% of the daily volume is about contracts with less than a week maturity, and up to 93% covers contracts with less than 3-month maturity. Contracts with maturities longer are less popular and make about 7% of the market. The last pie chart slices the trading volume by sector: 55% of the trading activity takes place in the inter-dealer market, 44% between dealers and clients, and only a tiny amount is intra clients. In the dealer-to-client segment, moreover, we document that more than 27.6% of the daily volume is with respect to non-dealer banks (typically acting on behalf of corporate firms and small financial players), 7.6% is with respect to real money investors, 4.1% with respect to hedge funds, 2% with respect to corporates, and less than 1% relative to central banks. As we explained in the previous section, there are more than 60,000 active counterparties in our dataset but we classify nearly half of them. The unclassified counterparties, however, cover roughly 2% of the overall volume.

Quarter-end Effects. The intermediation of FX forwards is generally considered as a low-risk business. But a low-risk activity will likely produce a lower return per unit of balance sheet space as opposed to higher-risk activity, thus requiring a greater balance sheet capacity to generate a comparable rate of return. Balance sheet costs – constraints related to the size rather than to composition of a bank's balance sheet – will potentially increase the opportunity costs for a bank and reduce its incentives to intermediate FX forwards.

An example of balance sheet costs is the non-risk-based leverage ratio which requires a bank to hold a minimum amount of capital in proportion to its consolidated assets, including non-balance sheet positions and cash held at the central bank. The impact of the leverage ratio is to some extent further amplified by the fact that dealers' are not allowed to net positions across similar transactions with different counterparties for accounting and capital reasons. Netting is generally permitted as long as the transactions have the same counterparty and settlement date. Although most of the ingredients regarding the leverage ratio requirement have been uniformly implemented across jurisdictions, some key features such as the reporting obligation at quarter-end can vary. For example, banks domiciled in the European Union (with some exceptions such the UK), Switzerland and Japan report the leverage ratio measured on the last day of each calendar quarter. In contrast, banks domiciled in the US disclose the daily average leverage ratio over the reference calendar quarter. In the UK, the subsidiaries of foreign banks as well as non-major local banks fall under the jurisdiction of the EU and, hence, report the leverage ratio measured on the last day of each calendar quarter. For major UK banks (including Spanish-owned Santander UK) is instead mandatory to report the end-of-month average leverage ratio over the reference calendar quarter since January 2016 (and the daily average since January 2017).

Quarter-end reporting obligations might introduce window-dressing incentives as banks might temporarily alter their balance sheet exposure by decreasing leverage around quarter-end dates while increasing it on other days. Du, Tepper, and Verdelhan (2018) provide evidence of quarter-end effects on CIP deviations. In particular, violations based on 1-week maturity FX forwards become very pronounced a week before and until the quarter-end dates whereas violations implied from 1-month maturity contracts tend to spike a month before and until the quarter-end dates. This happens as 1-week (1-month) maturity contracts intermediated during the last week (month) of the quarter will appear on the bank's balance sheet and the bank has a clear incentive to reduce their intermediation. In contrast, violations based on 3-month contracts are economically small at quarter end dates as 3-month contracts will always appear on the balance sheet at quarter ends irrespective of their execution date.

We overall document a similar pattern using FX forward volume as opposed to prices, thus complementing the findings of Du, Tepper, and Verdelhan (2018). In our exercise, we first sample 1-week, 1-month and 3-month maturity FX forwards, and then construct weekly volume data by summing up daily volume intra week in order to minimize the impact of day of week effects. Finally, we plot the average volume four weeks before and after the quarter-end window (two calendar weeks bracketing quarter-end dates) graphically marked with a shaded area, in Figure A.1. Quarter-end FX forward volume significantly drops for both 1-week (Panel A) and 1-month (Panel B) maturity contracts. Specifically, the decline for 1-week contracts amounts to approximately 18% and 16%, respectively, in the interdealer and dealer-client sector a week prior and until the quarter-end window. For 1-month contracts, volume deteriorates by more than 40% and 30%, respectively, for the two segments of the market a month prior and until the quarter-end window. Panel C displays the average volume for 3-month maturity contracts. This maturity is generally used by pension funds, insurance firms and mutual funds to hedge currency risk. As a result, one should expect an increase rather than a decline in volume at quarter-end. This is by and large what we uncover. This explains why quarter-end effects in CIP deviations are not very pronounced for this maturity.

To sum up, trading FX forwards cause an expansion of a dealer's balance sheet capacity and the disclosure of the leverage ratio leads to a capital charge for the bank subject to such constraint. As a result, dealers will find optimal to reduce the intermediation of FX forwards for those maturities appearing on the balance sheet at quarter ends.[10]

3.2 Other Data

We also employ other data in our analysis, and report summary statistics in Table A.1. In particular, we have obtained quarterly observations for the leverage ratio (Tier 1 capital over total assets) and capital ratio (Tier 1 capital over risk-weighted assets) of eleven major FX dealers regulated by the Prudential Regulation Authority (PRA), i.e., UK banks and subsidiaries of foreign banks in the UK. This list includes (in alphabetic order) Barclays, Citi, Credit Suisse, Goldman Sachs, HSBC, JP Morgan, Morgan Stanley, Nomura, Royal Bank of Scotland, Standard Chartered and UBS. EU dealer-banks (other than UK banks) are not part of this directory as their UK branches are not regulated by the PRA. As a result, we will only use the subset of dealer-banks for which we have data on leverage and capital ratio in our empirical analysis. The mean leverage ratio is close to 4% with a standard deviation of 1.4% whereas the mean capital ratio is slightly higher than 11% with a standard deviation of 1.8% .

We also use data on Bank Size measured as the log of a bank's total assets in levels, Liquid Asset Share quantified as is the holdings of liquid assets (i.e., cash and market loans) scaled by non-equity liabilities, and Deposit Share proxied by the fraction of the bank's balance

[10]Under the European Directive 2004/39/EC, known as MiFID, there was no uniform legal definition of FX forward. According to the general view, a contract that settles within two trading days ($T + 2$) should be considered as a spot contract whereas a contract with a $T + 7$ settlement period should be regarded as an FX forward contract. In between, EU member states have taken different approaches to classify currency contracts, and the same contract might be considered as a derivative in a EU Member State and as a spot transaction in another EU Member State. Starting from January 2017, however, the European Directive 2014/65/EU – referred to as MiFID II – has introduced a new regulatory framework and currency contracts with a settlement period less than three trading days should be regarded as spot contracts. The distinction between spot and forward contracts is indeed important as the former transactions are not subject to the leverage ratio requirement.

sheet financed with core deposits. These data are measured quarterly and are from the Bank of England. Finally, we collect data on 5-year CDS spreads and 1-month option's implied volatility of dealer banks from Bloomberg. We report summary statistics for these variables in Table A.1 in the Internet Appendix.

3.3 Contract-level Dollar Basis

Construction and Summary Statistics. We construct the contract-level dollar basis by synchronizing transaction prices on FX forwards with second level data on spot exchange rates and overnight index swap (OIS) interest rates from Thomson Reuters Tick History. Depending on the availability of OIS rates, we use all FX forwards between 1-week and 3-month maturity. For nonstandard maturity contracts (e.g., a 45-day FX forward), we rely on linearly interpolated OIS rates using the closest available tenors (e.g., 1-month and two-month OIS rates), and the resulting sample covers more than 5.5 million observations.

For each transaction, we measure the dollar basis on day t for currency i, dealer j, counterparty κ, and maturity ℓ by computing the deviations from CIP as follows

$$B_{ij\kappa\ell,t} = (1 + i_{i\ell,t}) - (1 + i^{\star}_{i\ell,t})\frac{F_{ij\kappa\ell,t}}{S_{i\ell,t}}, \tag{3}$$

where $i_{i\ell,t}$ is the dollar interest rate, $i^{\star}_{i\ell,t}$ the foreign interest rate, $S_{i\ell,t}$ the spot exchange rate, and $F_{ij\kappa\ell,t}$ the forward exchange rate. We omit an intraday (for all quantities) and a counterparty (for forwards only) subscript for simplicity. We ignore any bid-ask spread as the main objectives of our study is to understand why non-zero violations exist, what driving forces shift the supply and demand underlying such violations, and the types of constraints affecting the key participants. As a result, our matching exercise only uses mid quotes on interest rates and spot exchange rates. The forward prices can be either a bid or an ask price depending on recorded transaction.

Table 1 about here

Table 1 presents means with standard deviations in parenthesis of 1-week, 1-month and 3-

month CIP deviations in basis points (*bps*) per annum. The left-hand side columns (labeled as LIBOR daily) display the textbook style LIBOR-based CIP deviations (see, among many others, Bekaert and Hodrick, 2012; Du, Tepper, and Verdelhan, 2018). These violations are computed using LIBOR rates (i.e., the average interbank interest rate at which leading banks in London are prepared to lend to one another at 11am London time) coupled with spot and forward exchange rates recorded by Blomberg at 5pm London time. In the middle columns (labeled as OIS), we replace the LIBOR rates with the Overnight Index Swap (OIS) rates sampled at 11am London time using second-level data from Thomson Reuters Tick History. The right-hand side columns (labeled as Contract-level) present dollar basis based on trade-repository forward contracts between dealer banks and clients synchronized with second-level data on OIS rates and spot exchange rates from Thomson Reuters Tick History. To ease the comparison, we compute means and standard deviations of daily observations obtained by averaging intra-day CIP violations (results remain similar with volume-weighted intra-day averages). Panel A reports 1-week CIP deviations only for EUR, JPY and GBP as intra-day OIS rates are not available for other currencies. Panel B and Panel C display 1-month and 3-month CIP deviations, respectively, for all currency pairs. Despite using different data and sources, CIP deviations remain largely comparable.

For instance, the mean violation at 1-week maturity (see Panel A) for the British pound vis-à-vis the US dollar is about -21.77 *bps* per annum with LIBOR rates, -21.82 *bps* per annum with OIS rates, and -18.27 *bps* per annum when turning to transaction-level data. Similarly when we consider the cross-currency average, i.e., -34.79 *bps* per annum with LIBOR rates, -38.62 *bps* per annum with OIS rates, and -34.37 *bps* per annum with transaction-level data. The average 1-month violation (see Panel B) for the euro relative to the US dollar is about -40.49 *bps* per annum with LIBOR rates, -46.92 *bps* per annum with OIS rates, and -33.06 *bps* per annum with transaction-level data. The cross-currency average, moreover, equals -34.17 *bps* per annum with LIBOR rates, -37.44 *bps* per annum with OIS rates, and -29.15 *bps* per annum with transaction-level data. Panel C produces the same statistics for 3-month deviations and confirms the findings reported in previous panels as the cross-currency average CIP deviation goes from -25.33 *bps* pr annum with LIBOR rates to -32.36 *bps* per annum with transaction-level data.

Counterparty Heterogeneity. The aggregate dollar basis is virtually negative across all currencies and maturities, in line with the findings reported by the most recent literature (e.g., Du, Tepper, and Verdelhan, 2018). Little is known, however, on how the dollar basis behaves across different segments of the market. To answer this questions, we run as a preliminary exercise the following fixed effects panel regression

$$|B_{ij\kappa\ell,t}| = \alpha_i + \alpha_j + \alpha_\ell + \alpha_h + \alpha_t + \sum_{s=1}^{6} \delta_s + \varepsilon_{ij\kappa\ell,t}, \tag{4}$$

where $|B_{ij\kappa\ell,t+1}|$ denotes the absolute contract-level dollar basis recorded on day t for currency i, dealer j, and maturity ℓ; α comprises dealer, maturity, hour, currency, and time (calendar date) fixed effects, respectively; δ_s is a dummy variable that selects the contract-level dollar basis with respect to different client sectors (i.e., real money, nondealer banks, hedge funds, central banks, corporates, unclassified); and $Controls_t$ denotes a set of dealer-specific characteristics described in the previous section and summarized in Table A.1 in the Internet Appendix. Figure 5 displays a bar chart with the estimates of all coefficients δ_s including the 95% confidence interval based on standard errors clustered by currency and time dimension. The estimate of each coefficient δ_s can be interpreted as the additional dollar funding cost faced by each client sector relative to the interdealer market. Real money investors, for example, face the largest dollar funding cost over and above the interdealer one (16 *bps*), followed by corporate firms (10 *bps*), hedge funds (8 *bps*) and nondealer banks (7 *pba*). For central banks, in contrast, we find no statistically significant difference relative to dealer banks operating in the interdealer market.

Figure 5 about here

The previous exercise suggests that borrowing dollars in the FX market is more expensive for clients than dealer banks. How about in the interdealer market? Since US banks are less reliant on dollar funding than foreign banks, one would expect that the subsidiaries of US banks face a narrower dollar basis. To answer this question, we run the following fixed effects panel regression

$$|B_{ij\kappa\ell,t}| = \alpha_i + \alpha_j + \alpha_\ell + \alpha_h + \alpha_t + \delta_{us} + \varepsilon_{ij\kappa\ell,t}, \tag{5}$$

where δ_{us} is a dummy variable that equals one when the dealer is a US bank, and α refers to fixed effects. The dollar basis and the control variables are the same as in Equation (4). The estimate of δ_{us}, reported in Figure 5, is negative and statistically different from zero, suggesting that US dealers face a dollar basis that is 17 *bps* lower than non-US dealers.

4 Dollar Basis and Balance Sheet Costs

This section examines how the dollar basis responds to an increase in the regulatory balance sheet costs of major dealer banks. We focus on dealer-to-client transactions to construct our dollar basis as this allows us to control for unobserved counterparty characteristics. We first present estimates of fixed-effect panel regressions while controlling for observed dealer characteristics and unobserved time-variant currency and counterparty (sector or client) characteristics. We then move to difference-in-differences regressions to further control for omitted variables at the dealer level, thus offering a supply interpretation to our results. As a companion exercise, we also study the impact of balance sheet costs on the trading activity of the forward market.

4.1 Fixed-Effects Panel Regressions

4.1.1 Controlling for Unobserved Sector Characteristics

Our analysis begins with contract-level dollar basis whose construction is described in the previous section. We run fixed-effect panel regressions based on the following specification

$$|B_{ij\kappa\ell,t}| = \beta_1 L_{j,t-1} + \beta_2 C_{j,t-1} + \gamma' X_{j,t-1} + \alpha_i + \alpha_j + \alpha_\ell + \alpha_h + \alpha_{s,t} + \alpha_{i,s,t} + \varepsilon_{ij\kappa\ell,t} \tag{6}$$

where $B_{ij\kappa\ell,t}$ denotes all dollar basis recorded on day t for currency i, dealer j, counterparty κ and maturity ℓ (we omit any intraday subscript for simplicity), $|\cdot|$ is the absolute value operator, $L_{j,t}$ is the leverage ratio of dealer j defined as Tier 1 capital over total assets, $C_{j,t}$ is the capital ratio of dealer j defined as Tier 1 capital over risk-weighted assets, and

$X_{j,t}$ refers to a set of dealer-specific variables that includes *Bank Size* (the log of a bank's total assets in levels), *Liquid Asset Share* (the holdings of liquid assets such as cash and market loans scaled by non-equity liabilities), *Deposit Share* (the fraction of the banking organization's balance sheet financed with core deposits), Δ *Bank CDS* (the first difference of the 5-year CDS spread), and Δ *Bank IVOL* (the first difference of the 1-month option's implied volatility). We present a description of these variables in Table A.1 in the Internet Appendix. *De facto*, all right-hand side variables are lagged (up to a quarter) to avoid any reverse-causality, and higher-frequency observations are retrieved by forward filling. We further complement our specifications with both time-invariant and time-variant (interacted with calendar date) fixed effects. The former include currency (α_i), dealer (α_j), maturity (α_ℓ) and hour (α_h) fixed-effects. The latter comprises sector-time ($\alpha_{s,t}$) and currency-sector-time ($\alpha_{i,s,t}$) fixed effects.

TABLE 2 ABOUT HERE

Table 2 reports the coefficient estimates with standard errors clustered by currency and time dimension (in parentheses) associated with Equation (6). We find that the estimates of β_1 are always positive and highly statistically significant, even after controlling for dealer-specific variables including the capital ratio. This suggests that an increase in the leverage ratio of dealer banks is associated with a widening of the dollar basis. In contrast, estimates of the slope coefficient β_2 turn out to be statistically insignificant leading to conclude that the capital ratio has a negligible impact on the dollar basis.

Specification (1), for instance, uses the lagged leverage ratio as an explanatory variable together with dealer, maturity, hour, currency, and sector-time fixed effects. The estimate of the slope coefficient associated with the leverage ratio is 19.110 and is highly statistically significant (with a *t-stat* larger than 3). By interacting sector and time fixed effects, we control for all time-variant unobserved characteristics at sector level. This would include the heterogeneity in funding rates across different sectors which is otherwise hard to control for. For example, real money investors and corporate firms have different funding rates which are not directly observable. A sector-time fixed effect should account for such unobserved differences. Note that separate sector and time fixed effects are spanned by the sector-time fixed effects and are, thus, dropped here. Specification (2) introduces dealer-specific control variables and records qualitatively a similar outcome as the estimate of β_1 is 20.457 with a standard error of 3.480. In specification (3), our result remains robust to the inclusion of currency-sector-time fixed effect which accounts for time invariant currency and sector characteristics. The estimate of β_1 is 20.193 with a t-statistic above 3. In economic terms, the dollar basis widens approximately by 27 *bps* per annum when the lagged leverage ratio increases by a one standard deviation (i.e., $20.193 \times 1.41 \approx 28$).

Specifications (4)-(6) replace the leverage ratio with the (risk-weighted) capital ratio of dealer banks. While estimates of β_2 are highly statistically significant, their economic importance is fairly small. In specification (6), for example, the estimate of β_2 is 3.487 with standard error of 1.229. This roughly corresponds to a widening of the basis of 6 *bps* per annum when the lagged capital ratio rises by a standard deviation (i.e., $3.487 \times 1.80 \approx 6$). Specifications (7)-(9), finally, use both leverage and capital ratios as lagged explanatory variables. While these additional specifications confirm the statistical and economic significance of the leverage ratio, the capital ratio appears to be statistically insignificant and economically small. In specification (9), for example, the economic value of β_1 is close to 27 *bps* per annum whereas the economic value of β_2 is not even reaching 2 *bps* per annum.

4.1.2 Controlling for Unobserved Client Characteristics

The previous section documents a strong predictive relationship between the dollar basis and leverage ratio of dealer banks while controlling for unobserved sector-currency-time characteristics and observed dealer-specific variables. estimating this empirical relationship, however, faces an identification challenge as changes in the individual counterparty fundamentals could drive the widening of the dollar basis irrespective of dealer-specific variables, including balance sheet constraints. If so, we would be unable to give a supply interpretation to our estimates. We solve this problem in the spirit of Khwaja and Mian (2008), i.e., we control for all clients and currency characteristics through the inclusion of client-currency-time fixed effects. For its implementation, we collapse our contract-level dollar basis into volume-weighted weekly data in order to have clients with multiple trading relationship. This approach removes all confounding demand factors and is equivalent to asking whether the same counterparty in the same time period dealing with multiple dealer banks faces experiences a larger basis from the dealer bank with a relatively higher leverage ratio.

Similar to the specifications presented in Equation (6), we run the following panel regressions

$$|B_{ij\kappa,t}| = \beta_1 L_{j,t-1} + \beta_2 C_{j,t-1} + \gamma' X_{j,t-1} + \alpha_i + \alpha_j + \alpha_{\kappa,t} + \alpha_{i,\kappa,t} + \varepsilon_{ij\kappa,t}, \tag{7}$$

where we replace the contract-level dollar basis with volume-weighted dollar basis measured in week t ($B_{ij\kappa,t+1}$), the sector-time fixed effect with a client-time fixed effect ($\alpha_{\kappa,t}$), and the sector-currency-time fixed effect with a client-currency-time fixed effect ($\alpha_{i,\kappa,t}$) while dropping hour and maturity fixed effects.

Table 3 about here

The coefficient β_1 (β_2) measures the impact of the leverage (capital) ratio on the dollar basis, controlling for any observable and unobservable characteristics between dollar basis or within dollar basis over time. These estimates, reported in Table 3, by and large confirm the evidence recorded in the previous table. In specification (3), for example, the estimate of β_1 is 16.911, has a standard error of 3.985, and an economic significance of about 23 *bps* per annum. In specification (9), both β_1 and β_2 turn out to be statistically significant. The estimate of β_1 is 12.713 with a standard error of 3.330 whereas the estimate of β_2 is 4.135 with a standard error of 1.355. The economic value of β_1 (17 *bps* per annum), however, is substantially larger than the economic value of β_2 (7 *bps* per annum).

4.1.3 Trading Activity and Balance Sheet Costs

Dealer banks have an incentive to expand their balance sheet per unit of capital unless a backstop is at play. In response to a tighter constraint, banks can reduce their leverage exposure in two different ways. They can either increase their levels of regulatory capital (i.e., the numerator of the leverage ratio) or shrink their asset exposure (i.e., the denominator of the leverage ratio). While raising capital is generally regarded as good deleveraging by regulators, decreasing the asset side has potentially adverse effects if multiple banks simultaneously engage in slashing their activities. The fear that a tighter leverage ratio could lead to a bad deleveraging process (assuming that additional capital is not immediately available) was well summarized by a Reuters article on 5 August 2013 according to which *"[T]he sudden decision by regulators to focus on bank leverage ratios will hobble the industry's core trading businesses, dramatically slash the liquidity available in the capital markets, and bring about the most sweeping changes to investment banking seen in a generation."* Ultimately, how dealer banks adjust their balance sheets in response to tighter regulatory requirements is thus a critical empirical question to understand the real implications of the post-crisis financial regulation.

On the basis of these considerations, we complement our findings on the dollar basis with the following panel regressions

$$lnV_{ij\kappa,t} \times 100 = \beta_1 L_{j,t-1} + \beta_2 C_{j,t-1} + \gamma' X_{j,t-1} + \alpha_i + \alpha_j + \alpha_{\kappa,t} + \alpha_{i,\kappa,t} + \varepsilon_{ij\kappa,t}, \tag{8}$$

where $V_{ij\kappa,t}$ is the forward volume measured in week t for currency i, dealer j, and counterparty κ, and ln is the natural log operator. Moreover, we scale the dependent variable such that the coefficient β_1 (β_2) will approximately measure the percentage change in volume predicted by a unit increase in the leverage (capital) ratio. We report the estimates with standard errors (in parentheses) clustered by currency and time dimension in Table 4, and find that an increase in the leverage ratio of dealer banks goes hand-in-hand with a future fall in the trading activity of the forward market. The estimate of β_1 is always negative and highly statistically significant while controlling for observed dealer-specific characteristics and client-currency-time fixed effects.

Table 4 about here

For example, the estimate of β_1 in specification (3) equals -13.716 and is statistically significant at the 1% confidence level. Similarly when we control for the capital ratio in specification (9) as the estimate of β_1 is -12.942 and remains statistically significant at the 1% confidence level. The economic magnitude of these estimates if substantially large as a one standard deviation increase in the leverage ratio predicts a fall in volume of 17.6% for specification (3) and 16.7% for specification (9). The coefficient estimate associated with capital ratio turns out to be statistically insignificant and economically small when controlling for the leverage ratio. In specification (9), for example, the estimate of β_2 equals -0.762, has a standard errors of 0.955 and predicts a fall in volume of 1.3% when the capital ratio increases by a one standard deviation. To sum up, we find evidence that an increase in the leverage ratio predicts both a higher intermediation premium as well as fall in trading activity in the forward market.

4.2 Difference-in-Differences Regressions

The identification of a supply-side effect faces an additional challenge arising from the potential correlation of supply-side characteristics. For example, a higher leverage ratio could result from an active management of the balance sheet as opposed to the impact of a regulatory constraint. If so, the leverage ratio could proxy for other bank-related factors thus leading to a biased estimates of β_1. We alleviate the endogeneity concern due to possible time-varying omitted bank-related variables using a difference-in-differences approach based on plausibly exogenous variations resulting from the introduction of the UK leverage ratio framework in 2016 and the requirement on the public disclosure of the leverage ratio in January 2015. Ultimately, we will assess how affected dealer banks adjust their balance sheets in response to these exogenous shock compared to otherwise similar banks.

4.2.1 Controlling for Bank-related Omitted Variables

To enhance our identification in the presence of time-varying bank-related omitted variables, we study the dollar basis before and after the regulatory intervention between treated and untreated dealer banks using difference-in-difference regressions based on the following specification

$$|B_{ij\kappa,t}| = \beta D_p + \delta D_a + \gamma(D_p \times D_a) + \alpha_i + \alpha_j + \alpha_{\kappa,t} + \alpha_{i,\kappa,t} + \varepsilon_{ij\kappa,t}, \tag{9}$$

where $|B_{ij\kappa,t}|$ is the absolute volume-weighted dollar basis measured in week t for currency i, dealer j and counterparty κ, D_p is a dummy variable that selects observations after the regulatory intervention, D_a is a dummy variable that takes on the value of one for affected banks and 0 otherwise, and $D_p \times D_a$ is the interaction term between time and treatment group dummy variables. The coefficient γ measures the difference in the dollar basis between dealers that were subject to the regulatory intervention (the treatment group) and dealers that were exempted (the control group) such that a positive estimate of γ implies a widening of the dollar basis following the regulatory shocks. The specification also includes dealer and currency fixed effects to absorb time-invariant dealer and currency-specific characteristics, and/or client-time and client-currency-time fixed effects to account for observed and unobserved heterogeneity in time-varying client and currency characteristics. We estimate the difference-in-differences regressions via least-squares and cluster standard errors at the currency and time dimension.

We also examine the impact of a regulatory shock on the trading activity of the forward market using the same set of difference-in-difference regressions subsumed by Equation (9) as

$$lnV_{ij\kappa,t} \times 100 = \beta D_p + \delta D_a + \gamma(D_p \times D_a) + \alpha_i + \alpha_j + \alpha_{\kappa,t} + \alpha_{i,\kappa,t} + \varepsilon_{ij\kappa,t}, \tag{10}$$

except that we use the percentage log volume as dependent variable, i.e., we replace $|B_{ij\kappa,t}|$ with $lnV_{ij\kappa,t} \times 100$, where $V_{ij\kappa,t}$ is the forward volume measured in week t for currency i, dealer j, and counterparty κ. In this case, a negative estimate of γ would measure the percentage drop in volume for dealers subject to the regulatory intervention (the treatment group) relative to those dealers that were exempted (the control group) from the regulatory intervention.

4.2.2 The Introduction of the UK Leverage Ratio Framework

In our first difference-in-differences exercise, a plausibly exogenous shock arises from the introduction of the UK leverage ratio framework, which was announced by the regulator in early December 2015 following a review process initiated in July 2015. This reform came into play in January 2016, two years ahead of the Basel Committee's proposal, and only affected major UK banks. The subsidiaries of foreign banks (including all other domestic banks) continued to fall under the prescription of the EU legislation, in line with the Basel Committee's proposal. This regulatory change constitutes an ideal quasi-natural experiment to identify the impact of the leverage ratio rule on the dollar basis. It lends itself to a difference-in-differences exercise as it allows to identify a treatment and a control group of dealer banks. In our sample, four dealer banks – Barclays, HSBC, Royal Bank of Scotland and Standard Chartered – form our treatment group and the subsidiaries of seven international banks – Citi, Credit Suisse, Goldman Sachs, JP Morgan, Morgan Stanley, Nomura, and UBS – act as a pool of control group banks. While the selection within each block is not random, our banks are all categorized as global systemically important banks (G-SIBs) by the Financial Stability Board and the Basel Committee and, hence, should be regarded as largely comparable. This important as any causal inference would be compromised if our group of treated banks were systematically different, say in terms of business models or funding strategies, from our pool of control banks.

In addition to a minimum requirement, the UK framework introduced an important change to the reporting obligations for the leverage ratio. During a transitional period of 12 months ranging from January to December 2016, major UK banks were obliged to quantify the key ingredients for the calculation of the leverage ratio (i.e., capital and exposure measures) on the last day of each month during the reference calendar quarter and then average them. In contrast, other banks continued to report the leverage ratio recorded on the last day of each quarter. The aim of this end-of-month average rule was to reduce the ability of regulated banks to window-dress their balance sheet at quarter ends, thus making the leverage ratio rule more effective. While the minimum leverage ratio requirement could have been anticipated as the UK authorities announced its implementation in early December 2015 to let banks gradually adjust their balance sheet, banks had little incentives to adjust their reporting obligations ahead of the implementation date. As a result, we employ the change in the reporting obligations as a plausible exogenous variation that affected a group of banks while leaving other similar banks unaffected.

In our exercise, the pre-intervention period runs from 2 November to 18 December 2015 whereas the post-intervention period ranges between 11 January and 26 February 2016. Both periods are intended to capture two months of observations before and after the regulatory shock while removing the weeks bracketing the year-end to avoid, for instance, end of year volatility or tax-driven window dressing effects. Moreover, we construct volume-weighted dollar basis using forward contracts with maturities between one-week and one-month. This is to minimize any cross-period contamination as, for instance, a two-month forward contract traded on the December 15, 2015 (pre-intervention period) would affect the balance sheet of a dealer at the end of January 2016 (post-intervention period).[11]

Tables 5 about here

We report the difference-in-differences estimates of γ for the absolute dollar basis in Panel A of Table 5. These estimates – see specifications (1) and (2) – are always positive and statistically significant. For example, specification (2) employs currency-client-time fixed effects and uncover an estimate of 23.787 with a standard error of 9.084. This estimate implies that dealer banks subject to the UK leverage ratio framework faced a widening of their dollar basis approximately by 24 *bps* per annum relative to the dealer banks in the control group. As a robustness, we also run a placebo exercise by shifting the time window by a two-month period but uncover no statistically significant coefficient. This allows us to rule out the alternative that the dollar basis increase were part of an ongoing trend of deleveraging among low capitalized banks. In Panel B of 5, we presents the difference-in-difference estimates of γ using the percentage log volume (i.e., $lnV_{ij\kappa,t} \times 100$) as dependent variables but find no significant evidence that the regulatory intervention caused a drop in the trading activity of forward contracts. As an example, the estimate of γ is negative (-1.055) but statistically insignificant in specification (2). This is equivalent to saying that dealer banks subject to the UK leverage ratio framework faced approximately a 1% drop in volume relative the dealer banks in the control group.

[11] This exercise will mostly use dollar basis based on the most liquid currency pairs (i.e., EUR, GBP and JPY relative to USD) as for the least liquid currency pairs (i.e., AUD, CAD, and CHF vis-á-vis USD) we have no intrad-day data for less than a month interest rates (see the previous section for more details).

Figure 6 about here

We also visualize the impact of the regulatory intervention on the dollar basis in Figure 6. In particular, we report the difference in absolute dollar basis in *bps* per annum between the treatment and control group dealers before and after the change in reporting requirements. We also add to each bar the 95% confidence interval. While difference in absolute dollar basis were statistically insignificant during the pre-intervention period, they turn out to be statistically significant in the post-intervention period.

4.2.3 The Requirement on the Public Disclosure of the Leverage Ratio

The second difference-in-differences exercise exploits, as a plausibly exogenous shock, the requirement of banks to make detailed public disclosures about their Basel III leverage ratios starting from January 2015. While the leverage ratio rule was not mandatory at the time, banks had an incentive to adjust their leverage ratio around the expected minimum requirement. Failing to disclose a leverage ratio in line with the Basel Committee's expectation could have increased, for example, media attention and reputation risk for highly leveraged banks. It could have also affected the cost of capital as a higher level of financial disclosure reduces information asymmetries.

The public disclosure requirement may have created unexpected winners and losers in the cross-section of banks. Depending on their ex-ante leverage exposure, banks with a larger shortfall in regulatory capital may have experienced a marked deleveraging process, leading to a widening of their dollar basis and a fall in their trading activity. To measure the ex-ante leverage exposure of dealer banks, we rely on published account data obtained from Bank of England (see, Bank of England, 2015a) and construct a simple measure of leverage ratio as of December 2007, prior to the policy debate on excessive leverage in the banking sector (e.g., Draghi, 2008), using shareholders' claims to total assets. We then form a *treatment* and a *control* group of dealer banks using the cross-sectional median value of this naïve measure, with the former (latter) group including banks with a leverage ratio lying below (above) the median value. We then use the variation in the leverage ratio around January 2015 to test the causal impact of the leverage ratio requirement on both dollar basis and trading activity. The public disclosure requirement constitutes a shock under the assumption that it was not anticipated by banks. This assumption is, however, benign. If banks had fully anticipated the negative impact associated with the public disclosure requirement, they might have decided to adjust their leverage ratio prior to this disclosure obligation, thus leading to underestimate the effect of this rule change.

TABLES 6 ABOUT HERE

In our exercise, the pre-intervention period runs from 1 December 2014 (when our sample starts) to 19 December 2014 whereas the post-intervention period ranges between 12 January and 30 January 2016. Both periods are intended to capture a month of observations before and after the regulatory shock while removing the weeks bracketing the year-end. We use volume-weighted dollar basis using all available forward contracts. We report the difference-in-differences estimates of γ for the absolute dollar basis in Panel A of Table 6. These estimates – see specifications (1) and (2) – are always positive and statistically significant. For example, specification (2) employs currency-client-time fixed effects and uncover an estimate of 54.591 with a standard error of 13.306. This estimate implies that dealer banks with a low ex-ante leverage ratio faced a widening of their dollar basis by approximately 55 *bps* per annum relative to the dealer banks with a high ex-ante leverage ratio. As a robustness, we also run a placebo exercise by shifting the time window by a month period but uncover no statistically significant coefficient. This allows us to rule out the alternative that the dollar basis increase were part of an ongoing trend of deleveraging among low capitalized banks. In Panel B of 6, we presents the difference-in-difference estimates of γ using the percentage log volume (i.e., $lnV_{ij\kappa,t} \times 100$) as dependent variables and find significant evidence that the regulatory intervention caused a substantial drop in the trading activity of forward contracts. As an example, the estimate of γ in specification (2) is negative (-31.009) and statistically significant at the 1% confidence level. This translates into 31% drop in volume for affected dealer banks relative to the unaffected ones. Our results, moreover, remain unchanged if we rank dealer banks on the basis of the average simple leverage ratio between 2000 and 2007.

Overall, we confirm the role of the leverage ratio requirement as a determinant of the dollar basis.

5 Imbalance Between Hedging Demand and Supply

CIP violations happen because spot, forward and money market rates do not move together. While spot and money markets are way larger than FX derivatives markets and can be taken as given, it is a shift in the demand or supply of FX forwards that causes non-zero deviations (e.g., Borio, McCauley, McGuire, and Sushko, 2016).

So far, we find evidence that constraints to the supply of dollars in the forward market can drive up the magnitude of the CIP deviations. The leverage ratio is the prime suspect as it makes costly for bank dealers to expand their balance sheet capacity. But how about the role of demand conditions? The widening of the basis, for instance, could be attributed to the surge in net foreign currency hedging demand and, in particular, to the monetary policy divergence between the US and other countries (e.g., Sushko, Borio, McCauley, and McGuire, 2016). Higher interest rates in US as opposed to Japan and Europe, for instance, have created an incentive for investors to swap capital from local currency-denominated assets into dollar-denominated assets. At the same time, financial institutions hedge most of the their foreign currency investments, either in the FX swap market for short-term hedges or in the cross-currency swap market for longer-term hedges, thus causing an appreciation of the dollar in the spot market coupled with its depreciation in the forward market. If banks were unconstrained, as pointed out by Du, Tepper, and Verdelhan (2018), the supply of currency hedging should be perfectly elastic and CIP violations would be easily arbitraged away. Arbitraging the basis is indeed expensive as a balance-sheet-expanding trade requires a new pledge of capital and would be only justified if generates a return in excess of the bank's return on equity. In this section, we consider both the role of supply and demand shocks in order to better understand the key drivers behind the failure of the CIP deviations.

5.1 US Money Market Fund Reform

To shed light on the interaction between demand and supply, we consider the US reform of the money market funds and use the implementation date as an adverse supply shock that has increased the price of hedging. On 14 October 2016, the SEC completed the reform of the money market funds, an industry that was about to implode following the debacle of Lehman Brothers. The reform required prime funds, among the largest provider of unsecured banking loans, to introduce a floating net asset value structure and redemption fees in adverse market circumstances, thus making them less attractive. This reform caused a shift in the supply of dollars and nearly 1 trillion of US dollars were rerouted from prime funds into government funds, thus affecting the ability of foreign banks to fund themselves in dollars. European and Japanese banks were particularly exposed to this regulatory change and many of them were forced to use the FX swap market to fund their dollar assets.[12]

Table 8 about here

We consider a $-/+$ 3 days event window around the implementation date, and assume that the demand for hedging remain constant during this period. Panel B of Table 8 reports the estimates of a difference-in-difference regression where $|B_{ij\kappa\ell,t}|$, the transaction-level dollar basis in absolute value, acts as a dependent variable; MMF_t denotes a dummy variable that equals one starting from the implementation date of the reform; and the treatment effect is captured by the slope coefficient on the interaction terms $Leverage\ Ratio \times MMF_t$ and $Capital\ Ratio \times MMF_t$ for the leverage and capital ratio, respectively. The coefficient estimate for $Leverage\ Ratio \times MMF_t$ is positive and statistically different from zero, even after controlling for other factors (see specification (5) and (6)). In contrast, we find no statistical evidence for the interaction term between the capital ratio and MMF_t (specification (7) and (8)). Our findings suggest that shocks to the supply of dollars drive up the magnitude of the CIP deviations.

[12] Assets under management fell from about 1.5 trillion dollars in late 2015 to 0.4 trillion dollars in late 2016. Government funds were the main beneficiary as they increased their assets from 1 trillion to 2.1 trillion dollars during the same period.

5.2 Monetary Policy Shocks

Following Du, Tepper, and Verdelhan (2018), we also analyze the effect of monetary policy changes on the dollar basis. Specifically, we run a fixed-effects panel regression around the monetary policy announcements of the European Central Bank (ECB), and present the estimates in Table 7. The event window starts (ends) at 13:30 (15:30) Central European Time (CET). $\Delta B_{j,t}$ denotes the change in the euro-dollar basis. We measure the dollar basis at 13:30 (15:30) as the volume-weighted average of the transaction-level dollar basis between 11:30 and 13:30 (15:30 and 17:30) CET for each dealer. MP_t is the change in the 2-year German zero-yield minus the change in the 2-year US zero-yield between 13:30 and 15:30 CET from Reuters Tick History, and is common across all dealers.

Table 7 about here

In the first specification, MP_t is the only driving factor behind the dollar basis. Consistent with the evidence reported in Du, Tepper, and Verdelhan (2018), the coefficient estimate is positive and statistically different from zero, and this implies that the dollar basis widens as interest rates in the Euro Area fall (i.e., an increase in monetary policy divergence). In the second specification, we introduce the leverage ratio and the interaction term between the leverage ratio and the monetary policy shock. While the coefficient estimate on the monetary policy divergence loses its statistical significance, the coefficient estimate on the interaction term is positive and statistically significant at 10% level. The weak significance is likely due to a small number of observations. In the last specification, we replace the leverage ratio with the capital ratio by find no statistical evidence. In conclusion, we find that monetary policy divergence causes a widening of the basis especially when dealer banks face an increase in their balance costs.

5.3 Order Flows

FX Dealers act as financial intermediaries and facilitate trades by quoting prices at which they are willing to trade with clients. Trades between dealers and customers, however, are not transparent as prices and transaction volumes are only observed by the two transacting counterparties. This trading mechanism implies that customer orders may contain valuable information regarding their motivation for trading, attitude towards risk and investment horizon. The information content of customer orders is typically quantified by constructing the order flow, a measure of the net demand for a particular currency defined as the value of buyer-initiated orders minus the value of seller-initiated orders. We rely for our exercise on the buy/sell indicator for FX forwards available between November 2015 and December 2016.[13] Each transaction is signed positively or negatively depending on whether the initiator of the transaction (the non-quoting counterparty) is buying or selling US dollars such that a positive (negative) order flow indicates net demand (supply) of US dollars in the forward market. We aggregate order flows within each week and report descriptive statistics in Table 9. Order flows are measured in USD billions and recall that a positive (negative) order flow denotes net demand (supply) of US dollars in the forward market.

Table 9 about here

We document a net demand of US dollars for short-term maturity FX forwards, and a net supply of US dollars for longer-term maturity instruments. For real money investors, for example, we uncover an average positive order flow of 44.89 USD billions (with a t-stat of 16.80) for contracts up to a week maturity, and an average negative order flow of -5.43 USD billions (with a t-stat of -3.01) for maturities between 1-week and 1-month, which then becomes more pronounced between 1-month and 3-month. Nondealer banks share the same behavior as they exhibit a positive order flow up to 1-month maturity and a negative order flow for longer-maturities. Central banks and, to a lesser extent, hedge funds and corporate firms display an opposite pattern. What does order flow tell us about CIP deviations? Recall that investing in the US money market generates a lower return than investing in the foreign money market while hedging out any FX risk. Hence, an arbitrageur should borrow dollars,

[13] The buy/sell indicator is reported in the "Counterparty Side" field of the trade repository data as "B" and "S" for "Buy" and "Sell", respectively. When counterparties enter an FX trade, however, they are simultaneously buyer and seller of different legs of the trade. ESMA has introduced some reporting guidelines only in November 2015, and prior this date is difficult to correctly infer the directionality of the trade from the buyer/seller indicator. For this reason, we only construct order flow data starting from November 2015. See also Cielinska, Joseph, Shreyas, Tanner, and Vasios (2017) for the same issue.

buy foreign currency in the spot market, invest in the local money market and simultaneously hedge her currency risk away by buying dollars in the forward market. This means that a positive (negative) order flow can be associated with more arbitrageurs (hedgers) populating the FX forward market. One can then concludes that the long-term behavior of real money investors and nondealer banks is somewhat in line with the net foreign currency hedging demand story mentioned in the literature.

Sushko, Borio, McCauley, and McGuire (2016) propose a model that predicts that CIP deviations are proportional to FX hedging demand and the balance-sheet costs of FX exposures. This hedging demand may be driven, for example, by banks that run currency mismatches on their balance sheets, the strategic hedging decisions of institutional investors (such as insurance companies and pension funds), and non-financial firms' debt issuance across currencies (see also Borio, McCauley, McGuire, and Sushko, 2016; Arai, Makabe, Okawara, and Nagano, 2016; Nakaso, 2017). While the previous literature has been used aggregated proxies for the hedging demand of these players (e.g., using banks' funding gaps at the country level to proxy for bank's hedging demand), we will use order flow to directly measure it. Moreover, we will further interact order flow with balance sheet costs as this will help understand the key drivers of CIP deviations.

We run the following fixed-effect panel regression

$$\begin{aligned}\Delta B_{i\ell,t} &= \alpha + \beta_1 OF_{i\ell,t} + \beta_2 L_t + \beta_3 C_t \\ &\quad + \gamma_1 OF_{i\ell,t} \times Lt + \gamma_2 OF_{i\ell,t} \times C_t + Controls_t + \varepsilon_{i\ell,t+1},\end{aligned}$$

where $\Delta B_{i\ell,t}$ denotes the weekly change in the dollar basis for currency i and maturity ℓ (between 1-week and 1-year), α includes currency, maturity and time fixed effects, $OF_{i\ell,t}$ is the order flow for currency i and maturity ℓ, L_t (C_t) is the leverage (capital) ratio (volume-weighted across dealer banks), and $Controls_t$ is the usual list of control variables.

Table 10 about here

We report the estimates in Table 10. In the first two specifications, we find a positive and statistically significant coefficient estimate for order flow which calls for the following interpretation. The basis widens in response to an increase in the hedging demand (i.e., order flow moves south), consistent with the work of Sushko, Borio, McCauley, and McGuire (2016). When we add the leverage ratio and its interaction term with order flow (see specifications (3) and (4)), β_1 becomes negative whereas γ_1, the coefficient on the interaction term, turns out to be positive and statistically significant. Conversely, the capital ratio seem to play no role in this setting, in line with our previous finds. In conclusion, we find that hedging demand causes a widening of the basis especially when dealer banks face deleveraging pressure associate with balance costs.

6 Cross-Currency Basis and Balance Sheet Costs

Most of our analysis evolves around short-term dollar basis with a maturity ranging between one week and three months. In this section, we examine the basis based on cross-currency swaps whose maturity typically spans maturities between 1 and 20 years.

6.1 Data Description and Summary Statistics

A cross-currency swap is a derivative between two parties to exchange streams of interest payments in different currencies over an agreed period of time as well as principal amounts in different currencies at maturity using a pre-agreed exchange rate. Floating-for-floating currency swaps (interest rate on both legs are floating) are commonly used for major currency pairs and the parties involved are generally large international banks, either acting on their own or as agents for non-financial corporations.

Our confidential dataset also includes contract-level cross-currency swaps. This market, however, is far less liquid than the forward market. The BIS, for instance, reports a daily turnover of about 55 USD billions as April 2016 and we cover an average daily volume of 23 (24) USD billions as of April 2016 (full-sample period) as displayed in Figure A.2 in the Internet Appendix. Specifically, we observe $123,000$ transactions distributed as follows: 36% (EUR), 26% (GBP), 21% (JPY), 13% (AUD), 4% (CHF) and 1% (CAD). In contrast to the forward market, this market turns out to be more concentrated as 82% of the $123,000$ transactions are among dealers, 16% between dealers and clients (i.e., 1% with real money investors, 1% with hedge funds, less than 1% with corporates, 12% with non-dealer banks, and only 1% with unclassified clients), and less than 2% among clients. Nearly 17% of the transactions have a maturity less than a year, 16% between 1-year and 3-years, 14% between 3-years and 5-years, 24% between 5-years and 10-years, and 29% longer than 10-years. Figure A.3 in the Internet Appendix displays the decomposition of the currency swap market. The breakdown by currency pairs shows that more than 88% of the daily volume is concentrated on EUR, GBP and JPY against USD. In terms of maturities, 36% of the daily volume is about currency swaps with less than a year maturity, approximately 30% about contracts with a maturity between 1 and 5 years, 15% about contracts with a maturity between 5 and 10 years, and 18% about contracts with longer maturities.

The basis of a cross-currency swap is generally quoted on the foreign currency leg against the US dollar: 'paying' the basis means borrowing the foreign currency versus lending USD while 'receiving' the basis implies lending the foreign currency versus borrowing in USD. Consider, for instance, a 1-year JPYUSD cross-currency swap with a basis of -50 *bpa*. Here, the borrower of dollars will pay USD LIBOR and receive JPY LIBOR minus 50 *bpa* every three months for one year. A negative basis denotes a strong demand for US dollars as one party is willing to receive a lower interest rates on its foreign currency position. More in general, a non-zero basis goes hand in hand with potential deviations from the CIP condition at the long end of the yield curve as one party can take advantage from the swap beyond any exchange risk involved. Table A.6 in the Internet Appendix reports summary statistics of daily 1-year, 5-year, and 10-year cross-currency basis in *bpa* using both quotes from Bloomberg as in Du, Tepper, and Verdelhan (2018) and transaction-level data averaged intraday. The spreads are largely comparable across dataset: the cross-currency average based on Blomberg data ranges between -21 and -24 *bpa*, respectively, for the 1-year and 10-year cross-currency basis, whereas the cross-currency average based on transaction-level data goes from -23 and -26 *bpa*, respectively, for the 1-year and 10-year cross-currency basis.

6.2 Fixed-Effects Panel Regressions

We run fixed-effects panel regressions subsumed by the following specification

$$|B^{xccy}_{ij\kappa\ell,t}| = \beta_1 L_{j,t-1} + \beta_2 C_{j,t-1} + \gamma' X_{j,t-1} + \alpha_i + \alpha_j + \alpha_\ell + \alpha_h + \alpha_{s,t} + \alpha_{i,s,t} + \varepsilon_{ij\kappa\ell,t} \quad (11)$$

where $|B^{xccy}_{ij\kappa\ell,t}|$ denotes the absolute value of all transaction-level cross-currency basis recorded on day t for currency i, dealer j, counterparty κ, and maturity ℓ.

Table 11 about here

We report our estimates in Table 11 and find a positive and statistically significant coefficient estimate for the capital ratio. This implies that an increase in the capital ratio is followed by an increase in the basis, i.e., a widening of CIP deviations. The significance of the coefficient on the leverage ratio disappears when we control for the capital ratio in the same regression. This result seems consistent with the fact that these cross-currency basis swaps carry higher risk weight which in turn affect the calculation of the capital ratio (e.g., Du, Tepper, and Verdelhan, 2018). To corroborate this hypothesis and argue for causality we then focus on a regression on a variable that is reasonably exogenous with respect to the cross-currency basis, that is a specific form of UK capital ratio *requirements* set by the regulator at the dealer level. More specifically, UK capital requirements are split in 'Pillar 1' requirements that are common across banks, which are meant to capture credit and market risks; and bank-specific 'Pillar 2' requirements, which are set at the discretion of the regulator to capture risks that are not related to Pillar 1. On the basis of this argument and further empirical analysis, Forbes, Reinhardt, and Wieladek (2017) conclude that Pillar 2 requirements should reflect mostly non-balance-sheet risks and therefore should be exogenous with respect to bank balance-sheet variables.[14] We therefore analyse the impact of Pillar 2 requirements on the basis. The last two columns of Table 11 confirm the positive and statistically singificant impact of capital ratio requirements on the basis.

[14] See also Aiyar, Calomiris, Hooley, Korniyenko, and Wieladek (2014); and Aiyar, Calomiris, and Wieladek (2014).

7 Conclusions

The foreign exchange market—the most liquid financial markets by any means—has experienced large and persistent arbitrage deviations following the recent global financial crisis. These deviations arise from the failure of the covered interest rate parity condition, a simple no-arbitrage condition that simultaneously tie together the spot/forward exchange rate markets with the domestic/foreign money markets. Using a novel dataset of transaction level data on forward contracts, we find that CIP deviations can be explained by costly financial intermediation due to leverage constraints faced by major dealers in foreign exchange markets.

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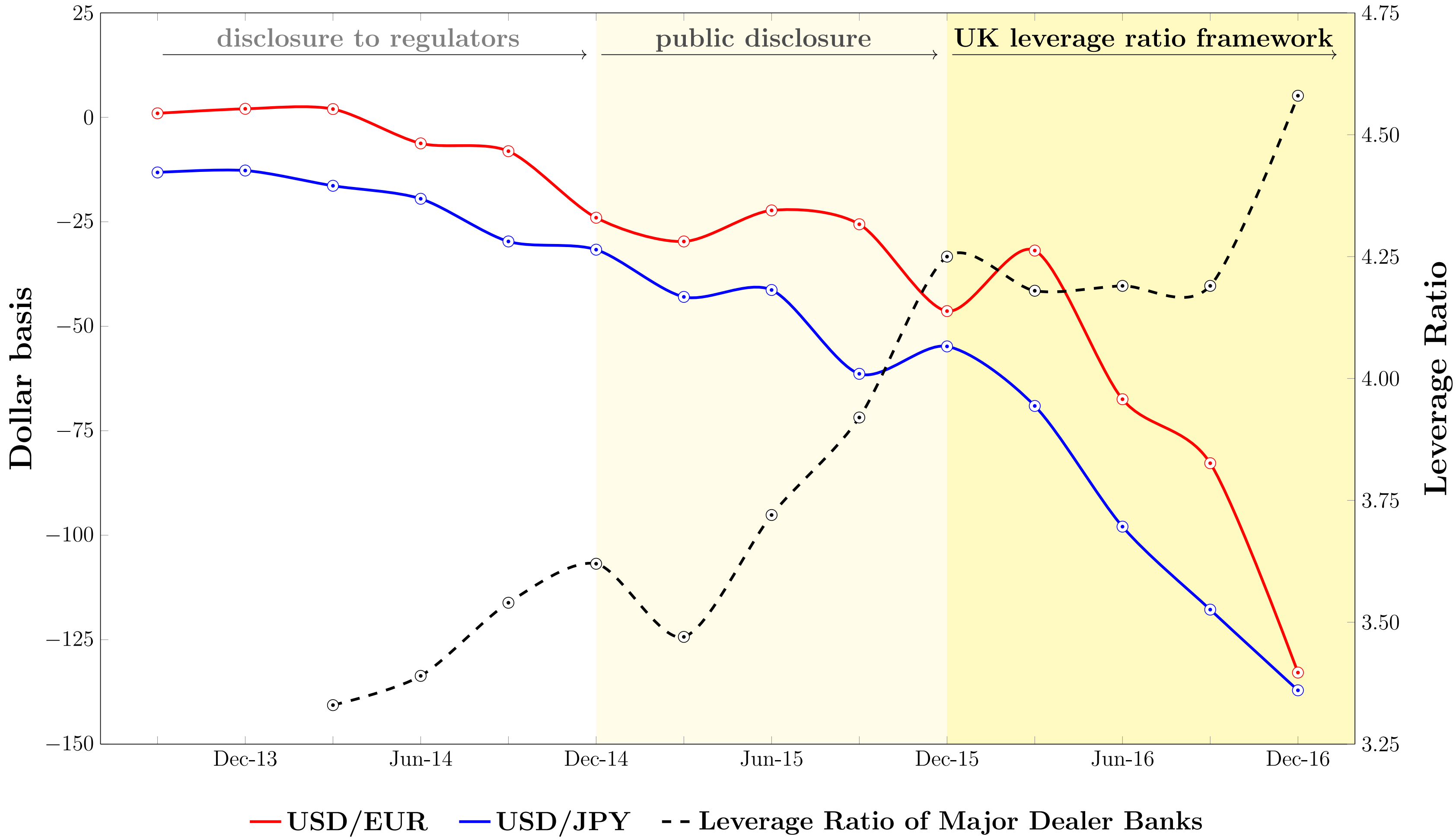

Figure 1: Dollar Basis and Leverage Ratio

The figure displays the dollar basis for the most liquid currency pairs (euro and yen against the dollar), and the average leverage ratio of major dealer banks in London, the global hub for FX trading. The basis is computed as difference between the one-month US dollar interest rate and its synthetic replication through the FX swap market at the end of each quarter (daily average of the last five business days) using spot, forward and Libor rates from Bloomberg. The leverage ratio is measured quarterly as high-quality capital over total asset exposure and is provided by from Bank of England. The basis is expressed in basis points per annum whereas the leverage ratio is in percentage points. The public disclosure of the leverage ratio started in January 2015. Prior to this date, banks were expected to disclose the leverage ratio to regulators. A mandatory minimum requirement for major UK banks was introduced in January 2016, two year ahead of the Basel Committee's proposal.

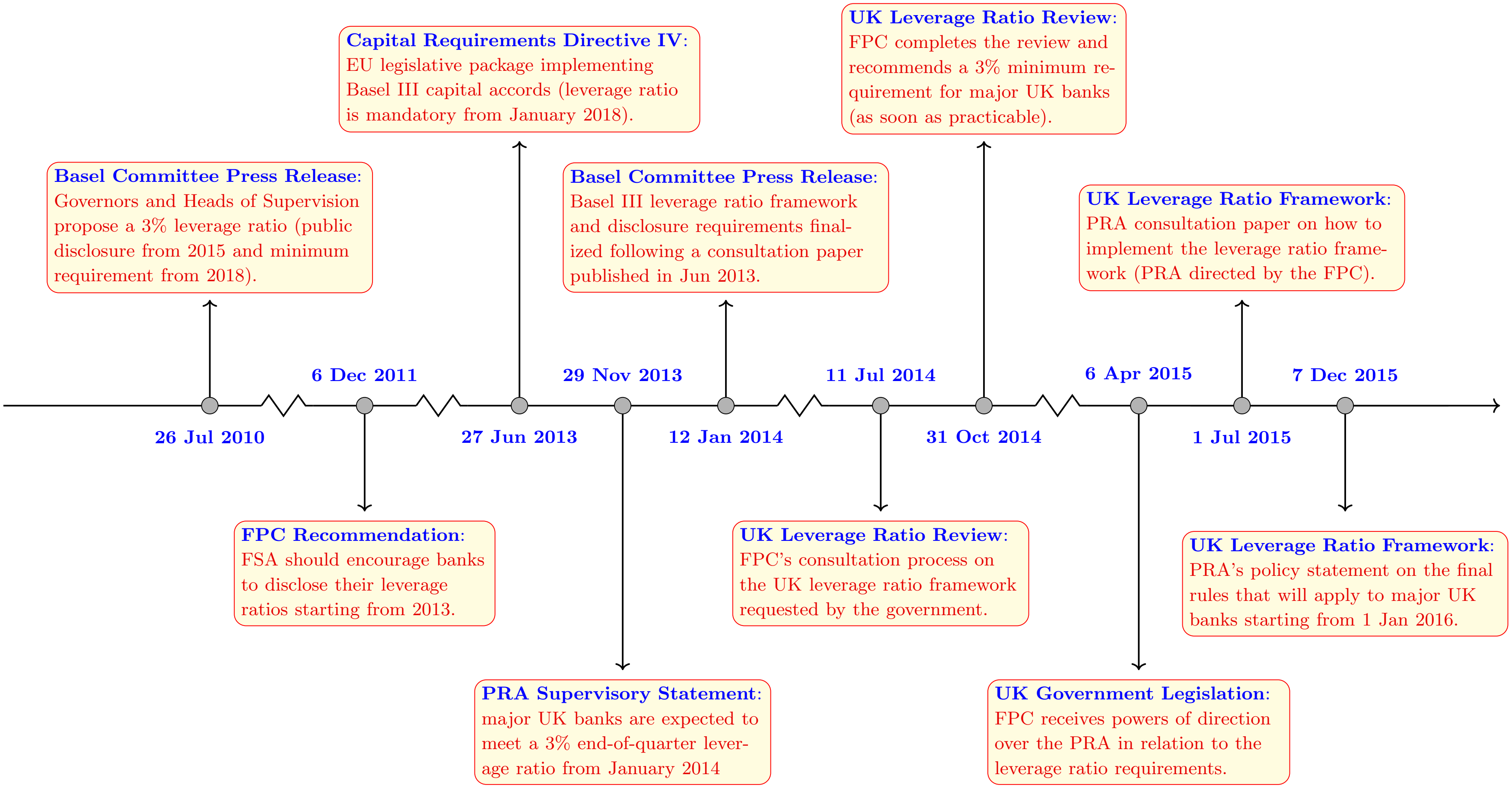

Figure 2: A Timeline of the UK Leverage Ratio Framework

This figure displays the key events leading to introduction of the UK leverage ratio framework. FSA is the Financial Services Authority, FPC is the Financial Policy Committee, and PRA is the Prudential Regulation Authority.

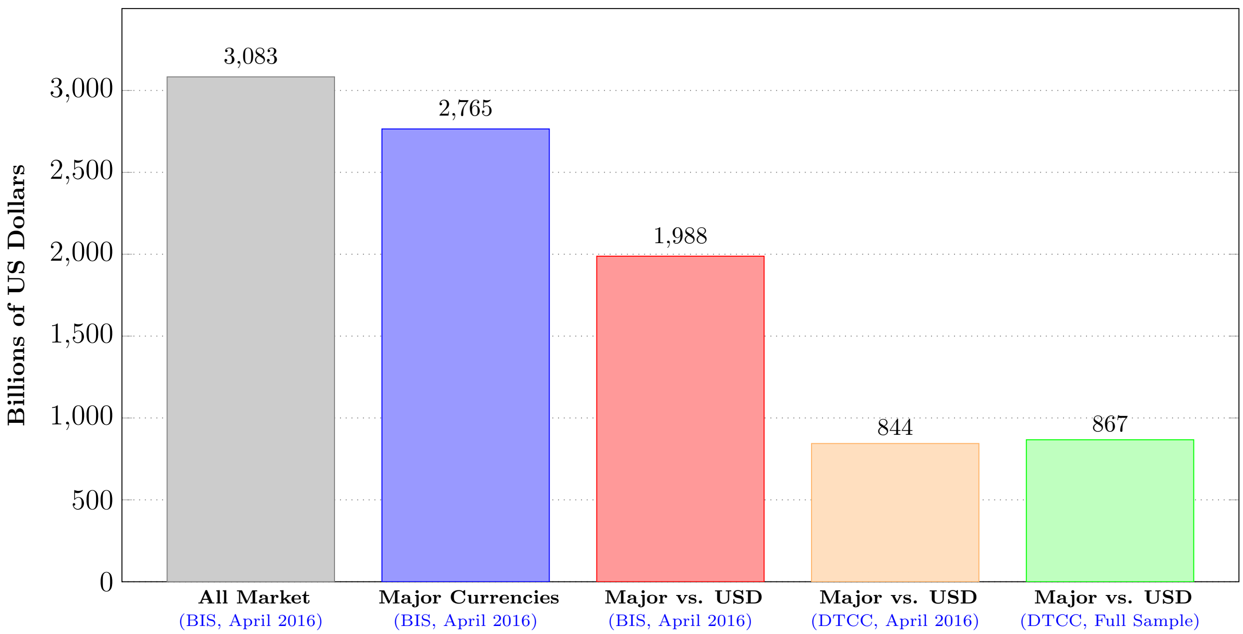

Figure 3: Daily Volume on Forward Contracts

This figure displays average daily volume based on the 2016 Triennal Central Bank Survey (BIS, 2016) and transaction-level data from the Depository Trust & Clearing Corporation (DTCC). The latter includes over-the-counter foreign exchange forward contracts (outright forwards and forward legs of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR). The sample comprises major currencies – Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) – relative to the US dollar (USD), and runs between December 2014 and December 2016.

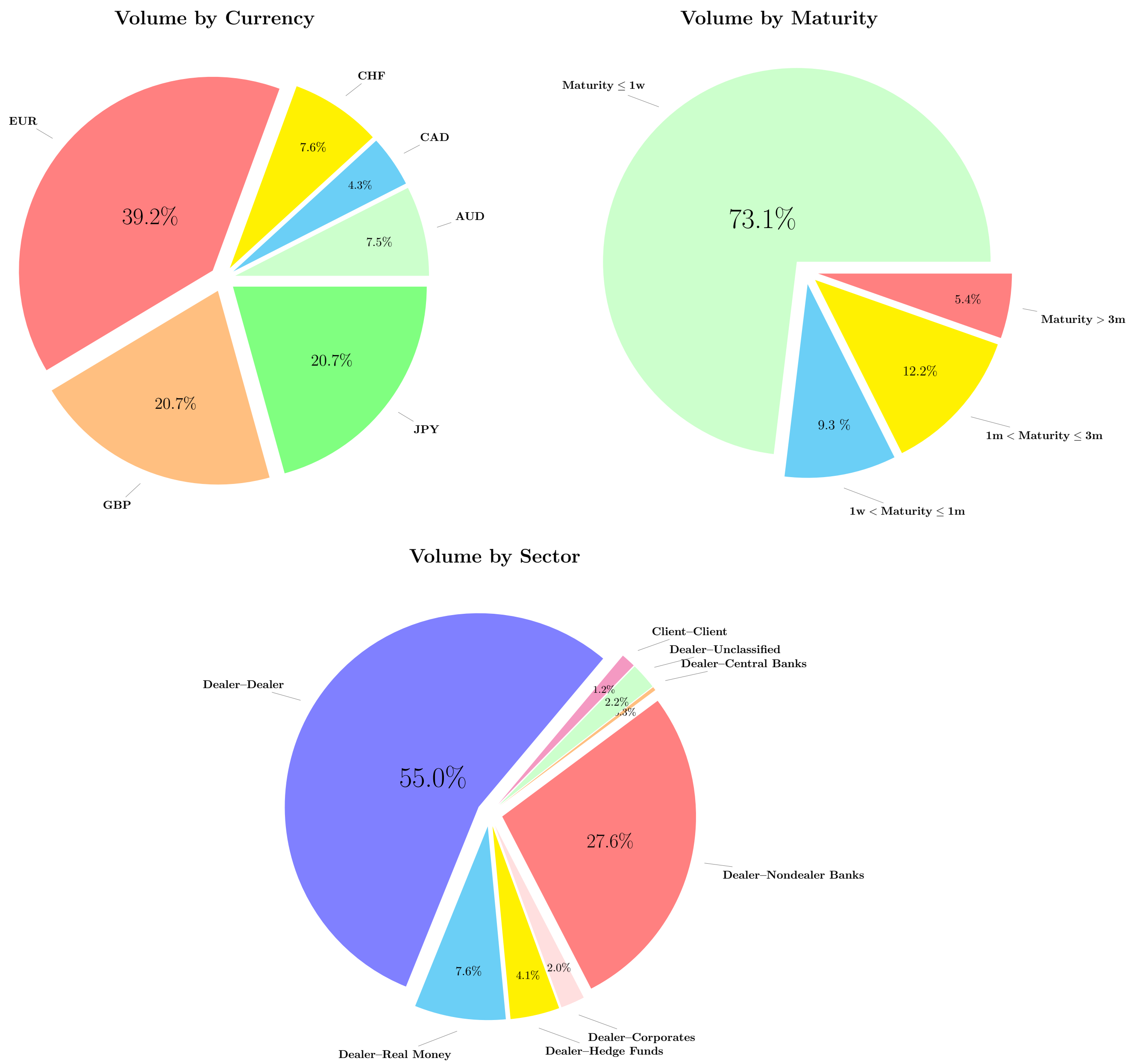

Figure 4: Breakdown of the FX Forward Volume

The figure displays currency, maturity and sector breakdown of daily volume on FX forwards. Volume is constructed using contract-level data from the Depository Trust & Clearing Corporation (DTCC) on OTC outright forwards and forward legs of FX swaps undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

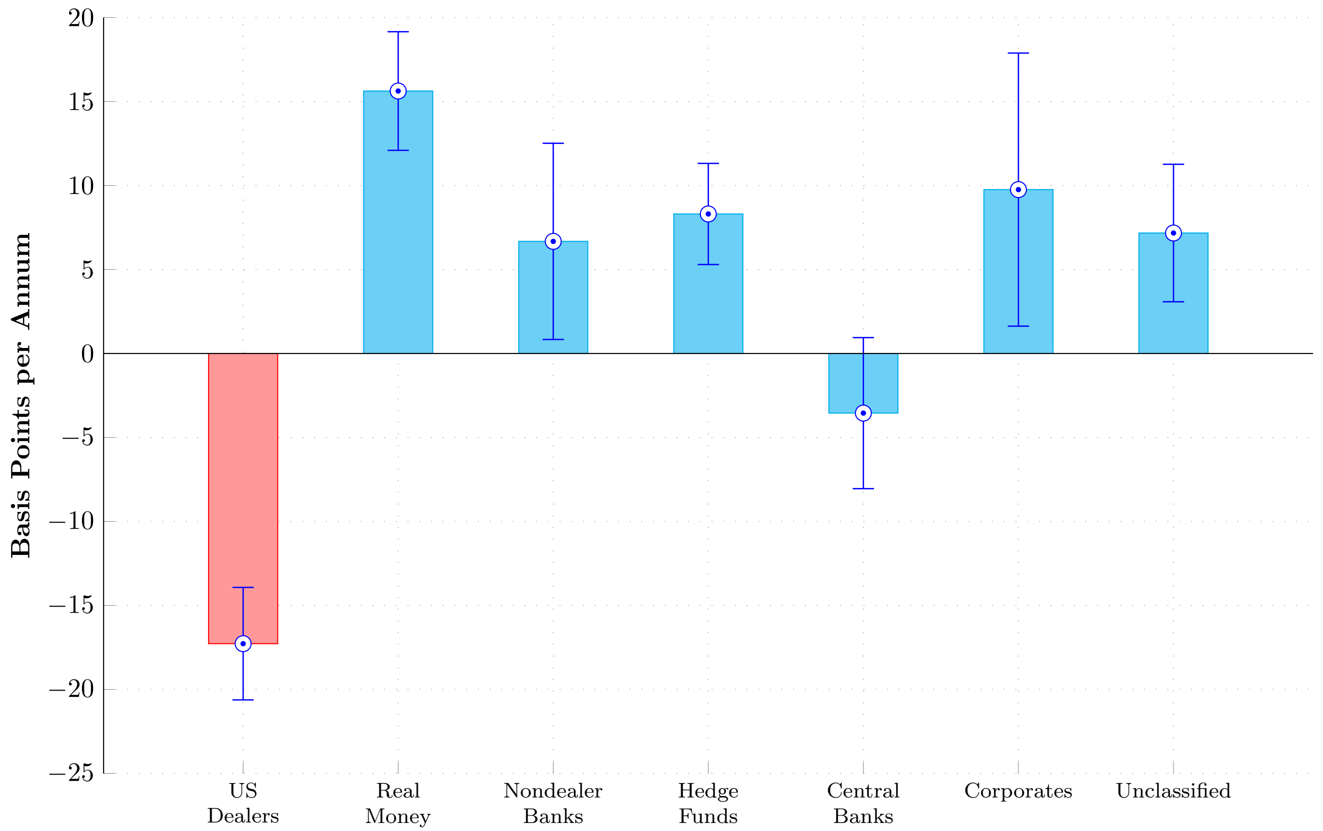

Figure 5: CIP Spread relative to the Interdealer Market

This figure displays coefficient estimates from fixed-effect panel regressions of transaction-level covered interest parity deviations in absolute value ($|CIP|$) on counterparty dummy variables and control variables in the Internet Appendix). The coefficients are expressed in basis points per annum and quantify CIP spreads between each segment of the market and the interdealer market. The error bar denotes the 95% confidence interval based on a standard error clustered by currency and time dimension. CIP deviations are constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on OTC FX forwards (outright forwards and forward leg of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. These transactions are synchronized at second level with OIS/spot exchange rates from Reuters Tick History. The sample runs between December 2014 and December 2016.

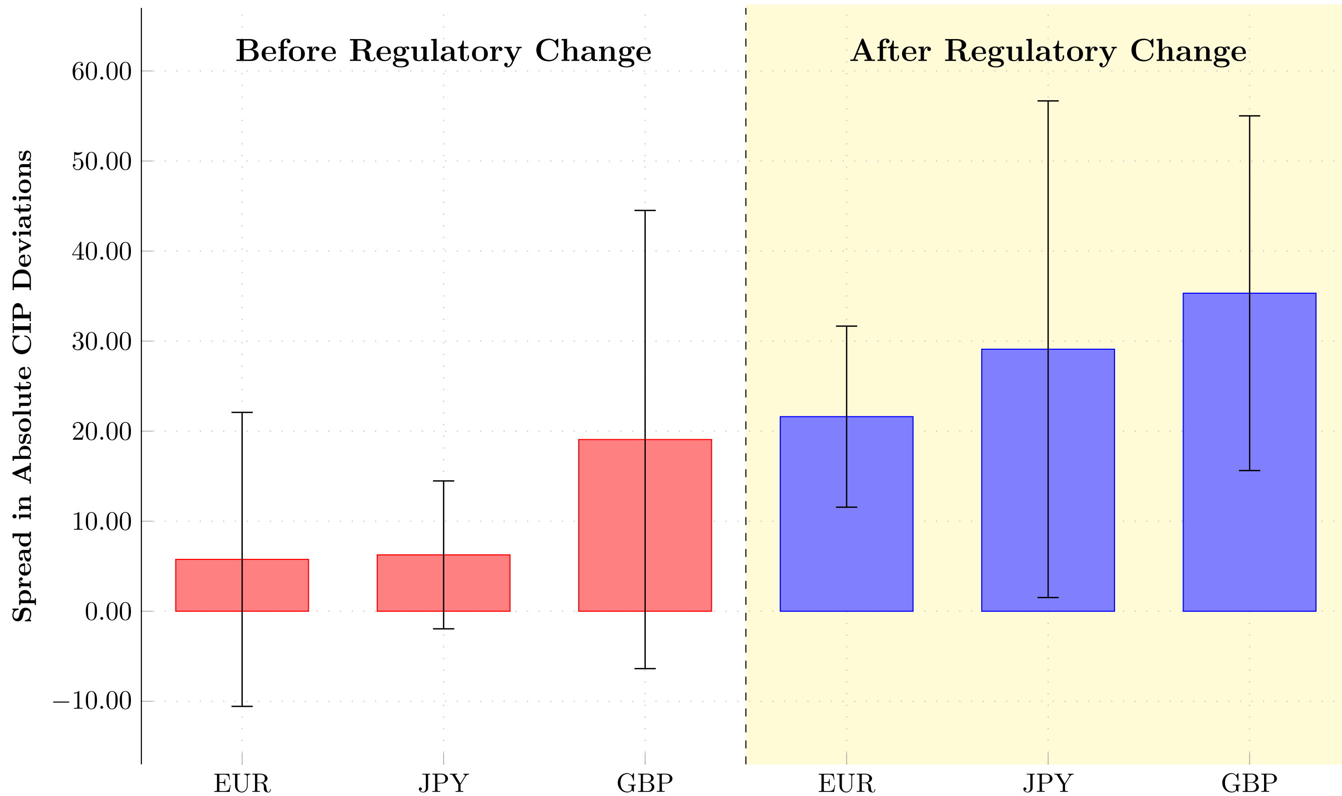

Figure 6: Regulatory Change and Covered Interest Parity (CIP) Deviations

This figure displays the difference in absolute CIP deviations (in *bps* per annum) between treated and untreated dealers before and after the introduction of the UK leverage ratio framework. Each bar also displays the 95% confidence interval. The treated group includes four UK banks whereas the control group comprises the subsidiaries of seven foreign banks operating in London. The pre-regulatory change period runs from 2 November 2015 to 18 December 2015 whereas the post-regulatory change period runs from 11 January 2016 to 26 February 2016. We exclude the year-end period running from 22 December 2015 to 8 January 2016. CIP deviations are measured using transaction-level FX forwards between 1-week and 1-month from Depository Trust & Clearing Corporation (DTCC) synchronized at second level with OIS and spot exchange rates from Reuters Tick History.

Table 1: Descriptive Statistics: Contract-level Dollar Basis

This table presents means and standard deviations (in parentheses) of daily dollar basis against major currencies. The basis is expressed in basis points per annum and is computed using (a) daily LIBOR rates and London closing spot/forward exchange rates from Bloomberg, (b) daily OIS rates (sampled at 11.00 am London time) from Reuters Tick History and London closing spot/forward exchange rates from Bloomberg, and (c) contract-level forwards (outright forwards and forward legs of FX swaps) between major dealer banks and clients from the Depository Trust & Clearing Corporation (DTCC) synchronized with second-level mid-quotes on OIS and spot exchange rates from Reuters Tick History (averaged intraday for ease of comparison). DTCC data consist of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR). The sample runs between December 2014 and December 2016.

	(a) LIBOR		(b) OIS		(c) Contract-level	
Panel A: 1-week Dollar Basis						
EUR	−32.75	(38.72)	−39.23	(48.11)	−35.27	(75.00)
GBP	−21.77	(28.95)	−21.82	(36.99)	−18.27	(99.62)
JPY	−49.86	(57.61)	−54.80	(66.47)	−49.57	(96.93)
Panel B: 1-month Dollar Basis						
AUD	10.61	(15.77)	12.97	(16.14)	−7.00	(53.90)
CAD	−41.76	(13.99)	−15.48	(12.23)	−10.37	(54.97)
CHF	−51.87	(39.02)	−85.30	(41.46)	−63.08	(53.64)
EUR	−40.49	(28.74)	−46.92	(33.42)	−33.06	(38.05)
GBP	−23.17	(22.94)	−24.19	(24.32)	−13.90	(43.04)
JPY	−58.33	(39.14)	−65.73	(41.05)	−47.51	(48.33)
Panel B: 3-month Dollar Basis						
AUD	5.89	(6.53)	10.69	(18.04)	3.07	(48.19)
CAD	−27.19	(6.24)	−13.13	(9.26)	−13.00	(48.68)
CHF	−40.91	(18.68)	−80.64	(24.99)	−72.86	(42.59)
EUR	−29.74	(12.98)	−43.23	(23.36)	−37.02	(28.29)
GBP	−13.07	(11.59)	−20.36	(16.54)	−13.64	(26.45)
JPY	−46.94	(17.50)	−64.60	(25.58)	−60.69	(37.87)

Table 2: Dollar Basis and Balance Sheet Costs: Contract-level Data

This table presents estimates from fixed effects panel regressions. The dependent variable is the absolute contract-level dollar basis described in Table 1. The set of independent variables is described in Table A.1 in the Internet Appendix. We include dealer, maturity, hour, currency, sector interacted with time (calendar date), and sector interacted with both currency and time fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016. Data are from the Depository Trust & Clearing Corporation (DTCC), Bank of England and Bloomberg.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	19.110***	20.457***	20.193***				17.445***	19.391***	18.949***
	(3.885)	(3.480)	(3.176)				(4.306)	(3.415)	(3.145)
Capital Ratio				3.797**	3.374**	3.487***	1.334	0.860	1.030
				(1.489)	(1.535)	(1.229)	(1.711)	(1.562)	(1.234)
Bank Size		38.126**	39.660*		18.062	20.680		37.938**	39.055*
		(15.577)	(21.455)		(19.349)	(23.617)		(14.956)	(20.558)
Liquid Asset Share		−1.123***	−1.377***		−1.347***	−1.585***		−1.099***	−1.352***
		(0.359)	(0.322)		(0.380)	(0.368)		(0.353)	(0.324)
Deposit Share		0.281	0.334**		0.178	0.229		0.282	0.336**
		(0.185)	(0.150)		(0.182)	(0.152)		(0.186)	(0.152)
Δ *Bank CDS*		−0.178	−0.053		−0.216	−0.089		−0.181	−0.056
		(0.216)	(0.167)		(0.218)	(0.168)		(0.213)	(0.165)
Δ *Bank IVOL*		−0.223	−0.209		−0.284	−0.264		−0.224	−0.209
		(0.179)	(0.150)		(0.182)	(0.157)		(0.179)	(0.151)
R^2	0.136	0.137	0.183	0.135	0.136	0.182	0.136	0.137	0.183
Obs	3,474,102	3,474,102	3,473,604	3,474,102	3,474,102	3,473,604	3,474,102	3,474,102	3,473,604
Dealer/Maturity/Hour	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Sector×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Sector×Time	N	N	Y	N	N	Y	N	N	Y

Table 3: Dollar Basis and Balance Sheet Costs: Controlling for Client Characteristics

This table presents estimates from fixed effects panel regressions. The dependent variable is the absolute volume-weighted dollar basis measured weekly using the contract-level dollar basis described in Table 1. The set of independent variables is described in Table A.1 in the Internet Appendix. We include dealer, currency, client interacted with time (calendar date), and client interacted with both currency and time fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016. Data are from the Depository Trust & Clearing Corporation (DTCC), Bank of England and Bloomberg.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	15.992***	16.198***	16.911***				12.177***	12.698***	12.713***
	(4.362)	(4.329)	(3.985)				(3.811)	(3.647)	(3.330)
Capital Ratio				5.269***	4.941***	5.655***	3.733***	3.410***	4.135***
				(1.473)	(1.499)	(1.535)	(1.276)	(1.256)	(1.355)
Bank Size		17.208*	21.123**		6.369	11.111		16.616*	20.386**
		(9.446)	(8.944)		(10.036)	(9.598)		(8.632)	(7.899)
Liquid Asset Share		−1.105***	−0.909***		−1.222***	−0.991***		−1.051**	−0.845*
		(0.390)	(0.331)		(0.432)	(0.365)		(0.391)	(0.330)
Deposit Share		0.234	0.377		0.106	0.253		0.216	0.356
		(0.167)	(0.234)		(0.170)	(0.245)		(0.165)	(0.235)
Δ *Bank CDS*		−0.052	0.006		−0.095	−0.040		−0.071	−0.018
		(0.183)	(0.148)		(0.184)	(0.145)		(0.178)	(0.154)
Δ *Bank IVOL*		−0.040	−0.341		−0.071	−0.355		−0.018	−0.311
		(0.322)	(0.352)		(0.322)	(0.354)		(0.321)	(0.351)
R^2	0.566	0.566	0.603	0.566	0.566	0.603	0.566	0.566	0.603
Obs	749,895	749,895	344,473	749,895	749,895	344,473	749,895	749,895	344,473
Dealer	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Client×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Client×Time	N	N	Y	N	N	Y	N	N	Y

Table 4: Volume and Balance Sheet Costs: Controlling for Client Characteristics

This table presents estimates from fixed effects panel regressions. The dependent variable is the percentage log volume of forward contracts between dealer banks and clients measured weekly. The set of independent variables is summarized in Table A.1 in the Internet Appendix. We include dealer, currency, client interacted with time (calendar date), and client interacted with both currency and time fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	−11.300***	−11.842***	−13.716***				−10.777***	−11.309***	−12.942***
	(1.706)	(1.459)	(1.419)				(1.391)	(1.147)	(0.499)
Capital Ratio				−1.871*	−1.883*	−2.310**	−0.512	−0.520	−0.762
				(1.055)	(1.008)	(0.917)	(1.044)	(1.023)	(0.955)
Bank Size		3.083	2.878		12.299	12.457		3.173	3.014
		(10.520)	(8.381)		(11.224)	(9.757)		(10.608)	(8.420)
Liquid Asset Share		−0.195	−0.204*		−0.051	−0.068		−0.203	−0.216*
		(0.156)	(0.121)		(0.178)	(0.115)		(0.151)	(0.123)
Deposit Share		−0.298***	−0.290*		−0.198	−0.181		−0.296**	−0.286*
		(0.102)	(0.168)		(0.120)	(0.220)		(0.146)	(0.167)
Δ *Bank CDS*		−0.062	−0.002		−0.038	0.026		−0.059	0.003
		(0.217)	(0.167)		(0.201)	(0.150)		(0.208)	(0.159)
Δ *Bank IVOL*		−0.159	−0.428***		−0.115	−0.389**		−0.162	−0.434***
		(0.199)	(0.153)		(0.213)	(0.165)		(0.222)	(0.158)
R^2	0.700	0.700	0.760	0.700	0.700	0.760	0.700	0.700	0.760
Obs	749,895	749,895	344,473	749,895	749,895	344,473	749,895	749,895	344,473
Dealer	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Client×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Client×Time	N	N	Y	N	N	Y	N	N	Y

Table 5: Difference-in-Differences: UK Leverage Ratio Framework

This table presents difference-in-differences estimates associated with the introduction of the UK leverage ratio framework on January 1, 2016. The dependent variable is the absolute volume-weighted dollar basis measured weekly. The sample only includes dealer-to-clients transactions. The *treatment group* includes major UK dealer banks whereas the *control group* comprises the subsidiaries of foreign dealer banks. The *pre-treatment* (*post-treatment*) period covers two months prior (post) to January 1, 2016. We exclude two weeks of data bracketing the year-end. The table also presents difference-in-differences estimates associated with a placebo date (April 1, 2016) using a two-month period prior (post) to this date as *pre-treatment* (*post-treatment*) sample. We include dealer, currency, client interacted with time (calendar date), and client interacted with both currency and time fixed effects. Standard errors are clustered by currency dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

	(1)	(2)	(3)	(4)
Panel A: Absolute Dollar Basis				
Affected Dealers × Post Regulatory Date	24.115***	23.787**		
	(6.207)	(9.084)		
Affected Dealers × Post Placebo Date			−28.010*	−19.957
			(14.924)	(14.305)
R^2	0.658	0.634	0.661	0.656
Obs	42,825	22,096	42,680	21,226
Panel B: Percentage Log Volume				
Affected Dealers × Post Regulatory Date	5.170	−1.055		
	(10.661)	(8.572)		
Affected Dealers × Post Placebo Date			2.920	0.992
			(2.921)	(1.752)
R^2	0.738	0.767	0.731	0.773
Obs	42,825	22,096	42,680	21,226
Dealer	Y	Y	Y	Y
Currency	Y	N	Y	N
Client×Time	Y	N	Y	N
Currency×Client×Time	N	Y	N	Y

Table 6: Difference-in-Differences: Public Disclosure

This table presents difference-in-differences estimates associated with the public disclosure of the leverage ratio on January 1, 2015. The dependent variable is the absolute volume-weighted dollar basis measured weekly. The sample only includes dealer-to-clients transactions. The *treatment group* includes dealer banks with a low (simple) leverage ratio as of December 2007 whereas the *control group* comprises dealer banks with a high (simple) leverage ratio as of December 2007. These groups are formed using the median value of a (simple) leverage ratio constructed as shareholder claims to total assets. The *pre-treatment* (*post-treatment*) period covers a month prior (post) to January 1, 2015. We exclude two weeks of data bracketing the year-end. The table also presents difference-in-differences estimates associated with a placebo date (February 1, 2016) using a month period prior (post) to this date as *pre-treatment* (*post-treatment*) sample. We include dealer, currency, client interacted with time (calendar date), and client interacted with both currency and time fixed effects. Standard errors are clustered by currency dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively.

Panel A: Absolute Dollar Basis				
	(1)	(2)	(3)	(4)
Affected Dealers × *Post Regulatory Date*	35.842*	54.591***		
	(18.995)	(13.306)		
Affected Dealers × *Post Placebo Date*			7.620	−10.545
			(25.318)	(21.446)
R^2	0.654	0.695	0.656	0.691
Obs	13,424	5,506	14,806	6,151
Panel B: Percentage Log Volume				
Affected Dealers × *Post Regulatory Date*	−26.972*	−31.009***		
	(16.222)	(8.194)		
Affected Dealers × *Post Placebo Date*			−6.488	6.292
			(9.819)	(15.906)
R^2	0.753	0.784	0.754	0.779
Obs	13,424	5,506	14,806	6,151
Dealer	Y	Y	Y	Y
Currency	Y	N	Y	N
Client×Time	Y	N	Y	N
Currency×Client×Time	N	Y	N	Y

Table 7: Dollar Basis and Monetary Policy Shocks

This table presents estimates from fixed-effects panel regressions around European Central Bank's monetary policy announcements. The event window starts (ends) at 13:30 (15:30) Central European Time (CET). The dependent variable consists of changes in covered interest parity deviations for the euro-dollar. CIP deviations at 13:30 (15:30) are constructed as the volume-weighted average of transaction-level CIP deviations between 11:30 and 13:30 (15:30 and 17:30) CET for each dealer. MPS is the change in the two-year German zero-yield minus the corresponding US zero-yield between 13:30 and 15:30 CET from Reuters Tick History, and is common across all dealers. LR (CR) is the dealer' quarter-end leverage (capital) ratio. CIP deviations are constructed using transaction-level data from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forward legs of FX swaps) synchronized at second level with OIS/spot exchange rates from Reuters Tick History. DTCC data consist of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR). Quarterly data on leverage and capital ratio for major dealers are from the Bank of England. The regressions include dealer, maturity, and quarter time fixed effects. Standard errors clustered by dealer and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample comprises 17 policy announcement between December 2014 and December 2016.

	(1)	(2)	(3)
MPS	32.951***	7.022	−18.633
	(7.965)	(7.489)	(46.886)
Leverage Ratio		0.000	
		(0.001)	
Capital Ratio			0.001
			(0.001)
Leverage Ratio × MPS		6.631*	
		(3.821)	
Capital Ratio × MPS			4.566
			(4.578)
R^2	0.106	0.117	0.118
Obs	146	146	146

Table 8: Dollar Basis and the US Money Market Fund Reform

This table presents estimates from fixed effects panel regressions. The dependent variable is the absolute contract-level dollar basis described in Table 1. The set of independent variables is described in Table A.1 in the Internet Appendix. MMF denotes a dummy variable equal to one from the implementation of the US money market fund reform on October 14, 2016. We include maturity, hour, currency, dealer and sector fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016 in Panel A, and ±3 days around the 14 October 2016 in Panel B. Data are from the Depository Trust & Clearing Corporation (DTCC), Bank of England and Bloomberg.

	Panel A: Full Sample		Panel B: Event Window (±3 days)					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
MMF	20.592***	21.294***	4.131**	6.076***	−4.731	−2.133	−17.451	−13.886
	(5.803)	(6.153)	(1.666)	(1.151)	(4.577)	(5.166)	(15.652)	(16.636)
Leverage Ratio					−1.425	−1.201		
					(1.431)	(1.349)		
Leverage Ratio × *MMF*					2.255**	2.002**		
					(0.861)	(0.949)		
Capital Ratio							−1.218	−0.875
							(1.679)	(1.429)
Capital Ratio × *MMF*							1.804	1.637
							(1.294)	(1.329)
Controls	N	Y	N	Y	N	Y	N	Y
R^2	0.090	0.092	0.151	0.151	0.141	0.144	0.141	0.144
Obs	3,587,502	3,587,502	37,537	37,537	37,537	37,537	37,537	37,537

Table 9: FX Forward Order Flows by Client Sector

This table presents summary statistics of weekly order flows for FX forwards between initiating clients and dealers. Order flow is the value of buyer-initiated orders minus the value of seller-initiated orders of US dollars against foreign currencies such that a positive (negative) order flow indicates net buying (selling) pressure of US dollars in the forward market by end-user clients. Order flows are constructed using transaction-level data and buying/selling indicators from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forwards leg of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. t-statistics based on clustered standard errors by currency and time dimension are reported in brackets. The sample runs at weekly frequency from December 2015 to December 2016.

Maturity	mean	t-stat	sdev	ac_1	mean	t-stat	sdev	ac_1
	Panel A: Real Money				Panel B: Nondealer Banks			
$1w \leq M \leq 1m$	-5.43	[-3.01]	23.52	-0.37	16.09	[8.85]	11.77	0.06
$1m < M \leq 3m$	-43.04	[-15.19]	21.30	-0.07	-4.86	[-1.64]	23.89	-0.10
$M \geq 3m$	-15.91	[-14.62]	7.42	0.21	-10.83	[-7.96]	11.60	0.02
	Panel C: Hedge Funds				Panel D: Central Banks			
$1w \leq M \leq 1m$	-4.19	[-3.28]	10.28	0.16	0.46	[3.60]	0.94	0.04
$1m < M \leq 3m$	-0.01	[-0.02]	6.62	0.04	0.75	[5.30]	0.95	-0.09
$M \geq 3m$	4.42	[3.06]	8.95	0.41	0.42	[4.96]	0.61	0.17
	Panel F: Corporates				Panel G: Unclassified			
$1w \leq M \leq 1m$	-2.90	[-6.02]	3.05	0.12	-0.45	[-1.66]	1.95	0.18
$1m < M \leq 3m$	-0.53	[-1.60]	2.99	0.13	-5.93	[-7.99]	7.58	-0.06
$M \geq 3m$	0.63	[2.17]	2.46	-0.02	0.07	[0.34]	1.47	0.34

Table 10: Dollar Basis and Order Flows

This table presents estimates from fixed-effects panel regression. The dependent variable is the change in the dollar basis measures weekly. The set of independent variables includes the order flow of forward contracts, leverage ratio, and capital ratio (beyond a number of additional control variables). Order flow is the value of buyer-initiated orders minus the value of seller-initiated orders of US dollars against foreign currencies, and a positive (negative) order flow indicates net buying (selling) pressure of US dollars in the forward market by end-user clients. Order flows are constructed using transaction-level data and buying/selling indicators from Depository Trust & Clearing Corporation (DTCC) on FX forwards (outright forwards and forwards leg of FX swaps) undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The regressions include currency, maturity, and time fixed effects. Standard errors clustered by currency and time dimension are reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs at weekly frequency between December 2015 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)
OrderFlow	0.061***	0.068***	−0.287	−0.240**	0.012	0.115
	(0.005)	(0.014)	(0.168)	(0.114)	(0.325)	(0.372)
Leverage Ratio			0.005	−0.036		
			(0.024)	(0.037)		
Capital Ratio					0.002	−0.008
					(0.008)	(0.014)
Leverage Ratio × *OrderFlow*			0.084**	0.074**		
			(0.041)	(0.029)		
Capital Ratio × *OrderFlow*					0.004	−0.004
					(0.025)	(0.029)
Controls	N	Y	N	Y	N	Y
R^2	0.010	0.052	0.010	0.053	0.010	0.052
Obs	1,338	1,338	1,338	1,338	1,338	1,338

Table 11: Dealer Balance Sheets and Cross-currency Basis Swaps

This table presents estimates from fixed effects panel regressions. The dependent variable is the absolute contract-level cross-currency basis described in Table A.6. The sample only includes dealer-to-clients transactions. The set of independent variables is summarized in Table A.1 in the Internet Appendix. We include dealer, maturity, hour, currency, sector interacted with time (date), and sector interacted with both currency and time (date) fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)
Leverage Ratio	4.695***		0.430		0.048
	(0.657)		(2.101)		(1.819)
Capital Ratio		3.657***	3.578***		
		(1.259)	(1.625)		
Capital Ratio Requirement				5.794***	5.788***
				(1.955)	(2.161)
Controls	Y	Y	Y	Y	Y
Obs	7,802	7,802	7,802	7,802	7,802
Dealer/Maturity/Hour	Y	Y	Y	Y	Y
Currency×Sector×Time	Y	Y	Y	Y	Y

Internet Appendix to

"Currency Mispricing and Dealer Balance Sheets"

(not for publication)

Abstract

This appendix presents supplementary results not included in the main body of the paper.

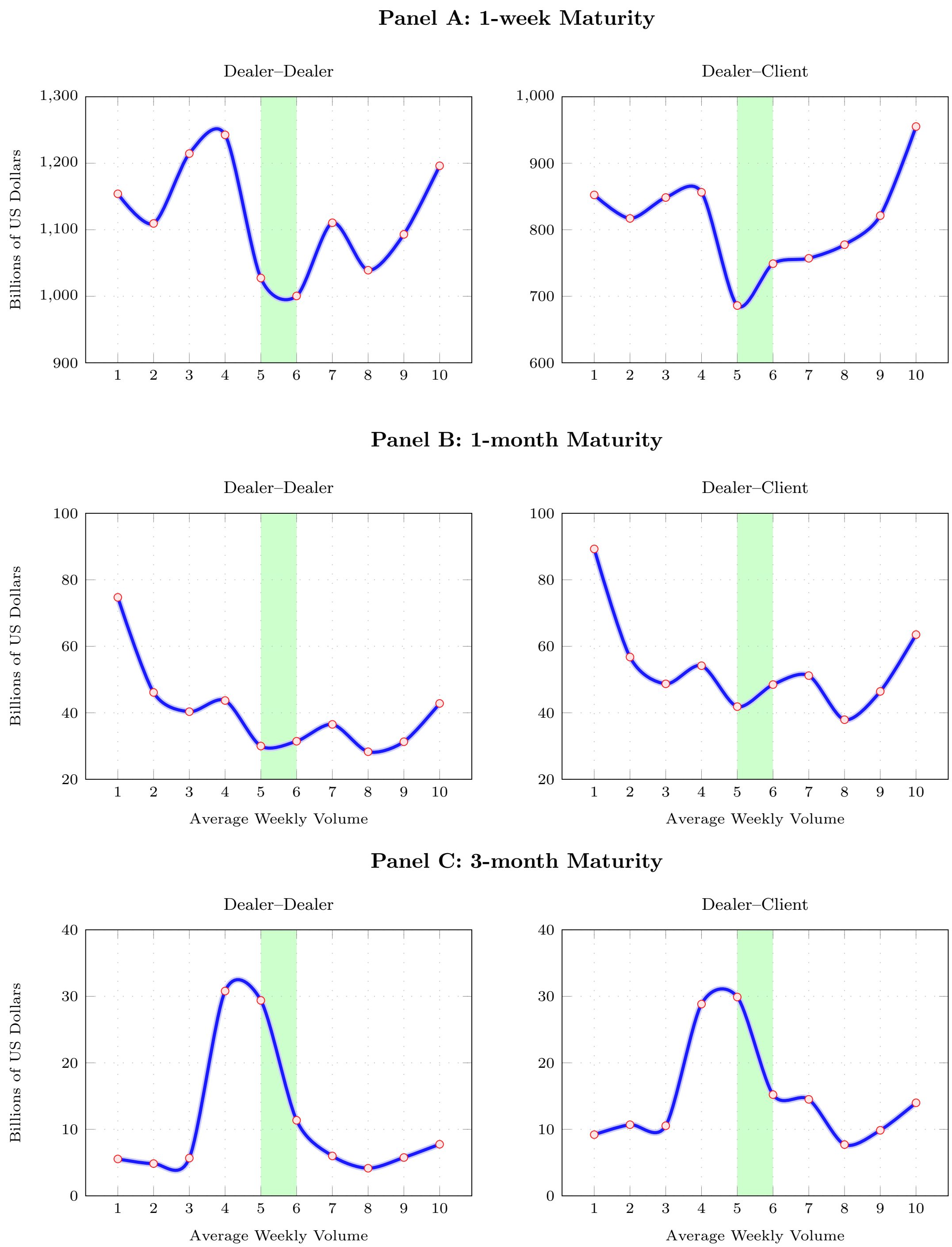

Figure A.1: Quarter-End Effect and FX Forward Volume

The figure displays weekly average volume (empty dots) on FX forwards before and after quarter-end periods (shaded area), i.e., the last two calendar weeks bracketing quarter ends. Volume is constructed using transaction-level data from the Depository Trust & Clearing Corporation (DTCC) on OTC outright forwards and forward legs of FX swaps undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

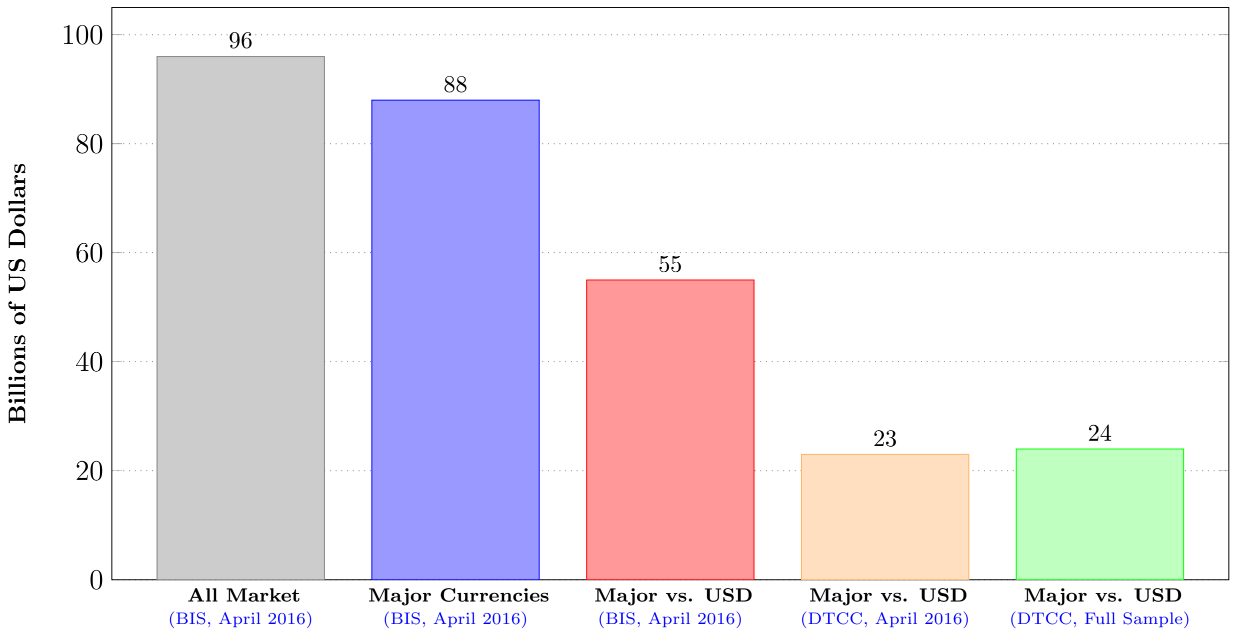

Figure A.2: Daily Volume on Cross-Currency Swaps

This figure displays average daily volume based on the 2016 Triennal Central Bank Survey (BIS, 2016) and transaction-level data from the Depository Trust & Clearing Corporation (DTCC). The latter includes over-the-counter cross-currency swaps undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR). The sample comprises major currencies – Australian dollar (AUD), Canadian dollar (CAD), Swiss franc (CHF), euro (EUR), British pound (GBP), Japanese yen (JPY) – relative to the US dollar (USD), and runs between December 2014 and December 2016.

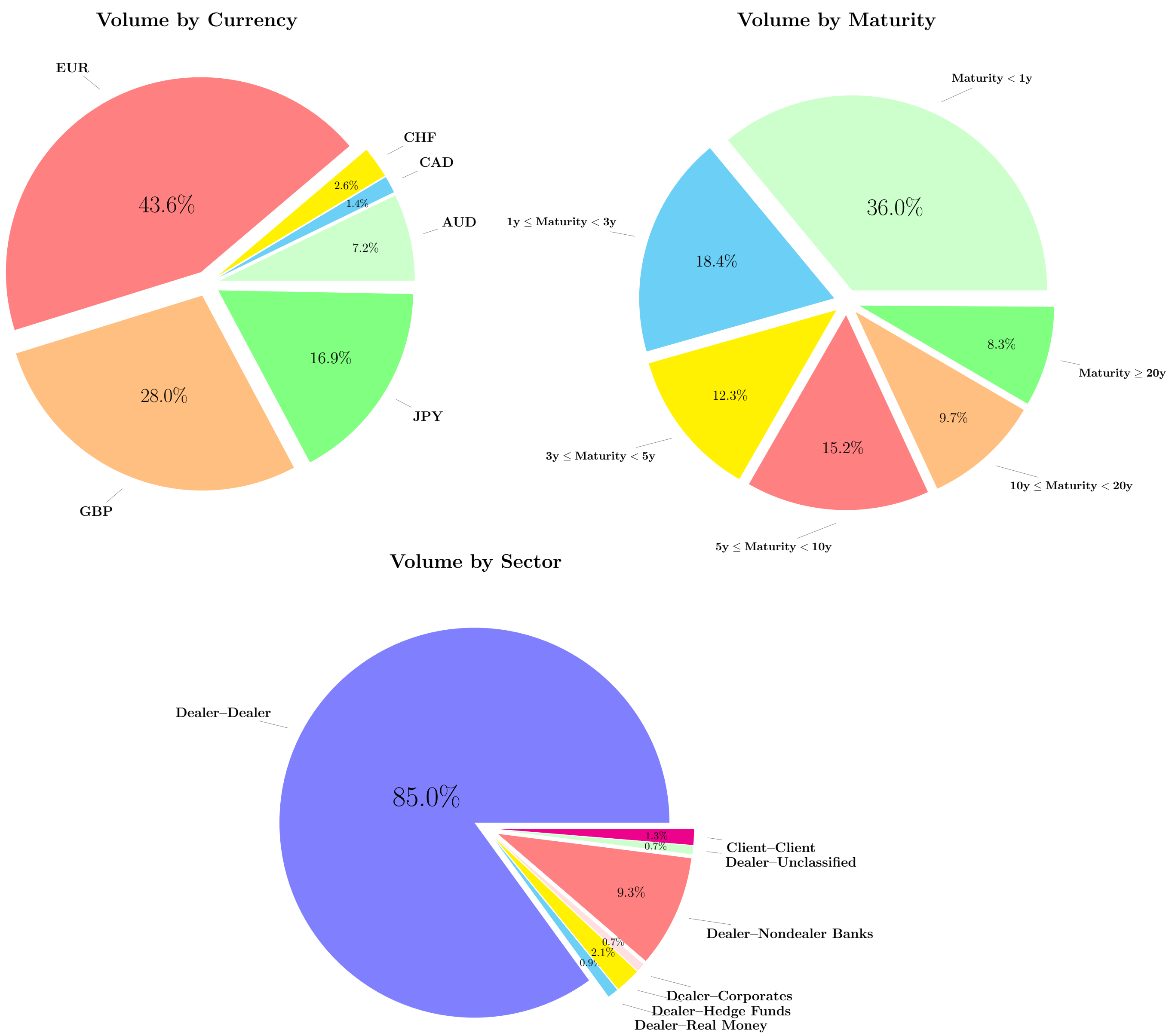

Figure A.3: Breakdown of Cross-Currency Swap Volume

The figure displays currency, maturity and sector breakdown of daily volume on cross-currency swaps. Volume is constructed using transaction-level data from the Depository Trust & Clearing Corporation (DTCC) on OTC cross-currency swaps undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

Table A.1: Descriptive Statistics of Dealer Banks' Variables

This table presents descriptive statistics of dealer-specific variables. *Leverage Ratio* is Tier 1 capital over total assets, *Capital Ratio* is Tier 1 capital over risk-weighted assets, *Capital Ratio Requirement* is the minimum requirement for the capital ratio, *Bank Size* is the log of a bank's total assets in levels, *Liquid Asset Share* is the holdings of liquid assets (i.e., cash and market loans) scaled by non-equity liabilities, and *Deposit Share* is the fraction of the banking organization's balance sheet financed with core deposits. These data are measured quarterly and are from the Bank of England. Δ *Bank CDS* is the weekly change in the 5-year CDS spread whereas Δ *Bank IVOL* is the weekly change in the 1-month option's implied volatility. These data are collected from Bloomberg. The sample runs between December 2014 and December 2016.

	mean	median	sdev	Q_{25}	Q_{75}
Leverage Ratio	3.92	3.80	1.41	3.02	4.61
Capital Ratio	11.42	10.93	1.80	10.05	12.67
Capital Ratio Requirement	7.05	6.25	3.35	5.15	7.25
Bank Size	25.12	25.51	2.03	23.73	26.85
Liquid Asset Share	19.82	20.85	15.77	7.73	26.18
Deposit Share	55.27	58.36	14.73	44.58	66.25
Δ *Bank CDS*	0.25	0.01	8.08	−3.10	3.33
Δ *Bank IVOL*	0.10	−0.09	3.83	−1.98	1.90

Table A.2: Summary Statistics of FX Forward Volume

This table presents summary statistics of weekly volume aggregated by currency and maturity. The volume is expressed in Billions of USD and is based on contract-level FX forwards (outright forwards and forward legs of FX swaps) from the Depository Trust & Clearing Corporation (DTCC). The sample runs between December 2014 to December 2016.

	AUD		CAD		CHF	
Maturity $\leq$ 1-*week*	273.87	(66.89)	156.88	(42.52)	269.28	(79.63)
1-*week* $<$ *Maturity* $\leq$ 1-*month*	29.79	(11.64)	18.33	(7.23)	31.91	(10.11)
1-*month* $<$ *Maturity* $\leq$ 3-*month*	34.28	(11.21)	29.20	(28.44)	34.59	(14.32)
Maturity $>$ 3-*month*	12.57	(6.98)	8.77	(5.61)	15.40	(6.99)
	EUR		GBP		JPY	
Maturity $\leq$ 1-*week*	1485.23	(289.31)	714.39	(136.28)	781.31	(190.75)
1-*week* $<$ *Maturity* $\leq$ 1-*month*	199.83	(55.23)	93.88	(38.32)	94.42	(36.70)
1-*month* $<$ *Maturity* $\leq$ 3-*month*	262.27	(81.06)	135.32	(52.09)	121.53	(46.77)
Maturity $>$ 3-*month*	116.60	(46.11)	61.66	(25.88)	57.45	(25.53)

Table A.3: Dealer-to-Client Dollar Basis and Balance Sheet Constraints: Major Currencies

This table presents estimates from fixed effects panel regressions. The dependent variable is the contract-level absolute dollar basis for the major currency pairs, i.e., euro, yen and pound against the dollar, using maturities between 1-week and 3-months. The sample only includes dealer-to-clients transactions. The set of independent variables is summarized in Table A.1 in the Internet Appendix. We include dealer, maturity, hour, currency, sector interacted with time (date), and currency interacted with both sector and time (date) fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	17.255***	18.283***	19.249***				15.698***	17.526***	18.478***
	(4.233)	(3.879)	(3.716)				(4.954)	(4.011)	(3.791)
Capital Ratio				3.418**	2.898*	3.051**	1.296	0.623	0.639
				(1.553)	(1.541)	(1.495)	(1.869)	(1.593)	(1.541)
Bank Size		48.385**	51.659**		32.643	35.085		47.941**	51.183**
		(18.795)	(21.925)		(20.310)	(23.361)		(17.422)	(20.491)
Liquid Asset Share		−1.238***	−1.362***		−1.445***	−1.576***		−1.225***	−1.350***
		(0.417)	(0.398)		(0.472)	(0.460)		(0.419)	(0.400)
Deposit Share		0.273	0.350**		0.170	0.240		0.273	0.350**
		(0.209)	(0.168)		(0.201)	(0.171)		(0.208)	(0.169)
Δ *Bank CDS*		−0.150	−0.074		−0.183	−0.108		−0.152	−0.075
		(0.274)	(0.233)		(0.276)	(0.227)		(0.272)	(0.233)
Δ *Bank IVOL*		−0.260	−0.227		−0.309	−0.277		−0.260	−0.226
		(0.211)	(0.181)		(0.216)	(0.190)		(0.212)	(0.182)
R^2	0.141	0.142	0.173	0.140	0.141	0.172	0.141	0.142	0.173
Obs	2,829,918	2,829,918	2,829,847	2,829,918	2,829,918	2,829,847	2,829,918	2,829,918	2,829,847
Dealer/Maturity/Hour	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Sector×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Sector×Time	N	N	Y	N	N	Y	N	N	Y

Table A.4: Dealer-to-Client Dollar Basis and Balance Sheet Constraints: Deposit Rates

This table presents estimates from fixed effects panel regressions. The dependent variable is the contract-level absolute dollar basis constructed using deposit rates as opposed to overnight index swap rates from Thomson Reuters Tick History using maturities between 1-month and 3-months. The sample only includes dealer-to-clients transactions. The set of independent variables is summarized in Table A.1 in the Internet Appendix. We include dealer, maturity, hour, currency, sector interacted with time (date), and currency interacted with both sector and time (date) fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	15.314***	15.506***	13.764***				14.641***	15.361***	13.357***
	(4.654)	(4.114)	(3.114)				(4.221)	(3.537)	(2.363)
Capital Ratio				2.620**	2.094*	2.057**	0.544	0.118	0.341
				(1.232)	(1.116)	(1.016)	(0.866)	(0.846)	(0.792)
Bank Size		16.829	17.061		−0.345	2.896		16.808	16.836
		(11.970)	(13.961)		(16.384)	(17.404)		(11.965)	(14.104)
Liquid Asset Share		−1.126***	−1.254***		−1.301***	−1.388***		−1.123***	−1.245***
		(0.232)	(0.208)		(0.213)	(0.208)		(0.222)	(0.202)
Deposit Share		0.249	0.244**		0.156	0.159		0.249*	0.244**
		(0.144)	(0.105)		(0.138)	(0.100)		(0.143)	(0.104)
Δ *Bank CDS*		−0.194	−0.093		−0.222	−0.116		−0.195	−0.094
		(0.193)	(0.150)		(0.200)	(0.153)		(0.192)	(0.149)
Δ *Bank IVOL*		−0.387*	−0.311*		−0.444*	−0.356*		−0.387*	−0.310*
		(0.188)	(0.150)		(0.192)	(0.153)		(0.188)	(0.151)
R^2	0.149	0.151	0.221	0.148	0.149	0.220	0.149	0.151	0.221
Obs	2,217,010	2,217,010	2,216,369	2,217,010	2,217,010	2,216,369	2,217,010	2,217,010	2,216,369
Dealer/Maturity/Hour	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Sector×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Sector×Time	N	N	Y	N	N	Y	N	N	Y

Table A.5: Controlling for Demand Conditions at Client Level: Major Currencies

This table presents estimates from fixed effects panel regressions. The dependent variable is the absolute volume-weighted dollar basis measured weekly for the major currency pairs, i.e., euro, yen and pound against the dollar, using between 1-week and 3-months. The sample only includes dealer-to-clients transactions. The set of independent variables is summarized in Table A.1 in the Internet Appendix. We include dealer, currency, sector interacted with time (date), and currency interacted with both sector and time (date) fixed effects. Standard errors are clustered by currency and time dimension, and reported in parentheses. The superscripts *, **, and *** indicate statistical significance at 10%, 5%, and 1%, respectively. The sample runs between December 2014 and December 2016.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Leverage Ratio	15.955***	16.359***	16.855***				11.610***	12.335***	12.630***
	(4.927)	(4.835)	(4.444)				(4.140)	(3.937)	(3.678)
Capital Ratio				5.731***	5.434***	5.679***	4.296***	3.968***	4.176***
				(1.642)	(1.655)	(1.767)	(1.352)	(1.330)	(1.535)
Bank Size		17.946	25.183***		8.143	16.002*		17.295	24.652*
		(12.005)	(8.549)		(12.598)	(8.838)		(10.772)	(7.024)
Liquid Asset Share		−0.993**	−0.745**		−1.088**	−0.819**		−0.930**	−0.678**
		(0.396)	(0.290)		(0.443)	(0.335)		(0.391)	(0.287)
Deposit Share		0.399**	0.534*		0.281**	0.412		0.381**	0.511
		(0.172)	(0.299)		(0.175)	(0.316)		(0.172)	(0.302)
Δ *Bank CDS*		−0.004	0.028		−0.053	−0.022		−0.028	0.002
		(0.201)	(0.206)		(0.212)	(0.262)		(0.236)	(0.249)
Δ *Bank IVOL*		−0.147	−0.417		−0.173	−0.433		−0.125	−0.390
		(0.361)	(0.423)		(0.363)	(0.455)		(0.363)	(0.423)
R^2	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.599	0.600
Obs	566,814	566,814	299,763	566,814	566,814	299,763	566,814	566,814	299,763
Dealer	Y	Y	Y	Y	Y	Y	Y	Y	Y
Currency	Y	Y	N	Y	Y	N	Y	Y	N
Client×Time	Y	Y	N	Y	Y	N	Y	Y	N
Currency×Client×Time	N	N	Y	N	N	Y	N	N	Y

Table A.6: Descriptive Statistics: Contract-level Cross-currency Basis

This table presents average cross-currency basis with standard deviations in parentheses for major currencies relative to the US dollar. The basis is measured in basis points per annum using (a) daily data from Bloomberg as in Du, Tepper, and Verdelhan (2018), and (b) contract-level cross-currency basis swaps between dealer banks and clients from the Depository Trust & Clearing Corporation (DTCC), and then averaged intraday for ease of comparison. DTCC data consists of OTC transactions undertaken by UK legal entities under the European Market Infrastructure Regulation (EMIR) on derivatives. The sample runs between December 2014 and December 2016.

	Bloomberg Quotes		Contract-level	
Panel A: 1-year Cross-currency Basis				
AUD	17.97	(10.15)	18.47	(12.00)
CAD	−12.52	(10.22)	−12.25	(11.52)
CHF	−35.39	(10.63)	−34.54	(14.58)
EUR	−31.92	(9.89)	−35.54	(26.66)
GBP	−9.45	(7.03)	−11.39	(13.55)
JPY	−55.41	(15.97)	−53.54	(22.85)
Panel B: 5-year cross currency basis				
AUD	23.96	(7.25)	25.57	(13.33)
CAD	1.24	(7.74)	2.00	(8.54)
CHF	−44.28	(13.56)	−42.88	(16.71)
EUR	−36.13	(11.02)	−33.89	(18.57)
GBP	−8.32	(4.76)	−7.84	(8.37)
JPY	−73.74	(18.32)	−71.37	(20.09)
Panel D: 10-year cross currency basis				
AUD	23.60	(8.14)	23.94	(8.86)
CAD	9.59	(13.08)	6.58	(3.00)
CHF	−53.96	(17.51)	−54.11	(18.50)
EUR	−37.36	(11.32)	−33.79	(15.48)
GBP	−10.32	(3.78)	−8.77	(5.10)
JPY	−74.33	(17.24)	−71.90	(16.65)